

International Marine Engineering

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THE RIVER STEAMER S. S. BROWN.

BY H. H. BROWN.

The *S. S. Brown* is a steel hull, western river, packet boat, designed and built by James Rees & Sons, of Pittsburg, Pa., for the Memphis & Vicksburg division of the Arkansas River Packet Company. She is a stern-wheel boat, similar in general arrangement and appearance to the ordinary type of western river shallow draft boat. There are four decks; the main, boiler,

able and commodious passenger accommodations, and every modern convenience for the safety and comfort of passengers.

The principal dimensions of the boat are as follows:

Length over all (including wheel)	255 feet.
“ between perpendiculars	230 “
Beam, molded	44 “

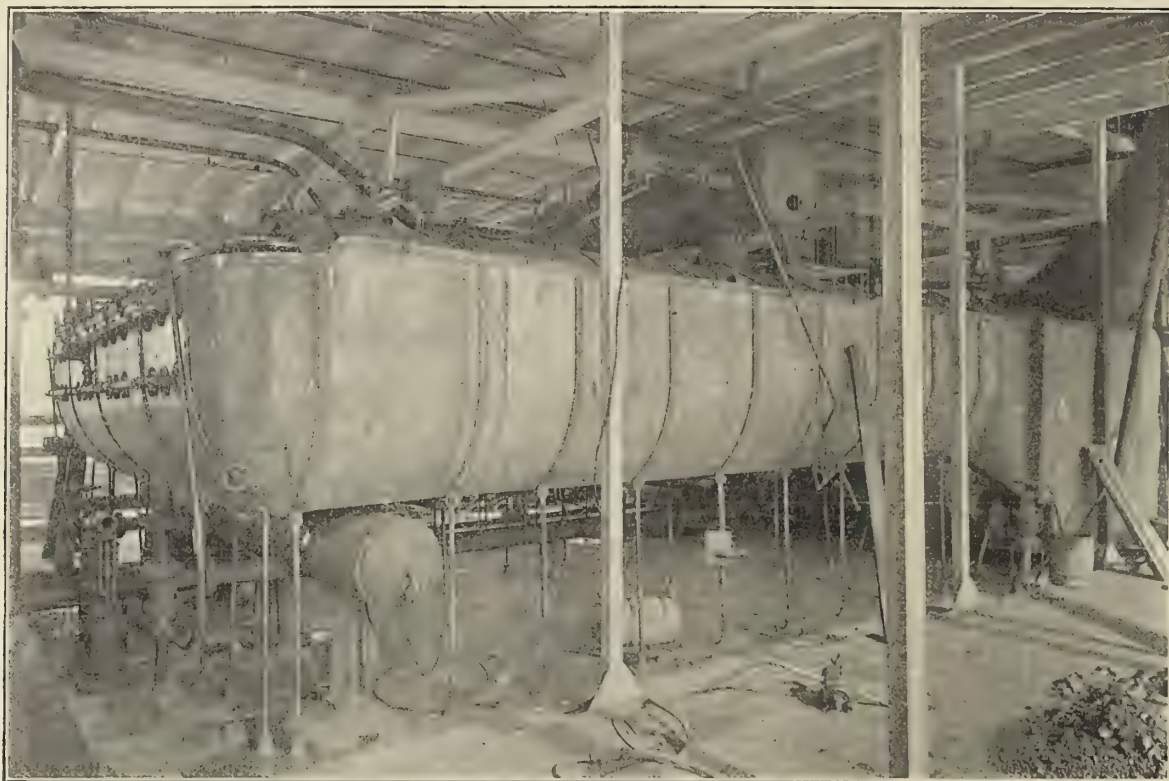


THE MAIN CABIN ON THE UPPER DECK, 165 FEET LONG AND 15 FEET BROAD.

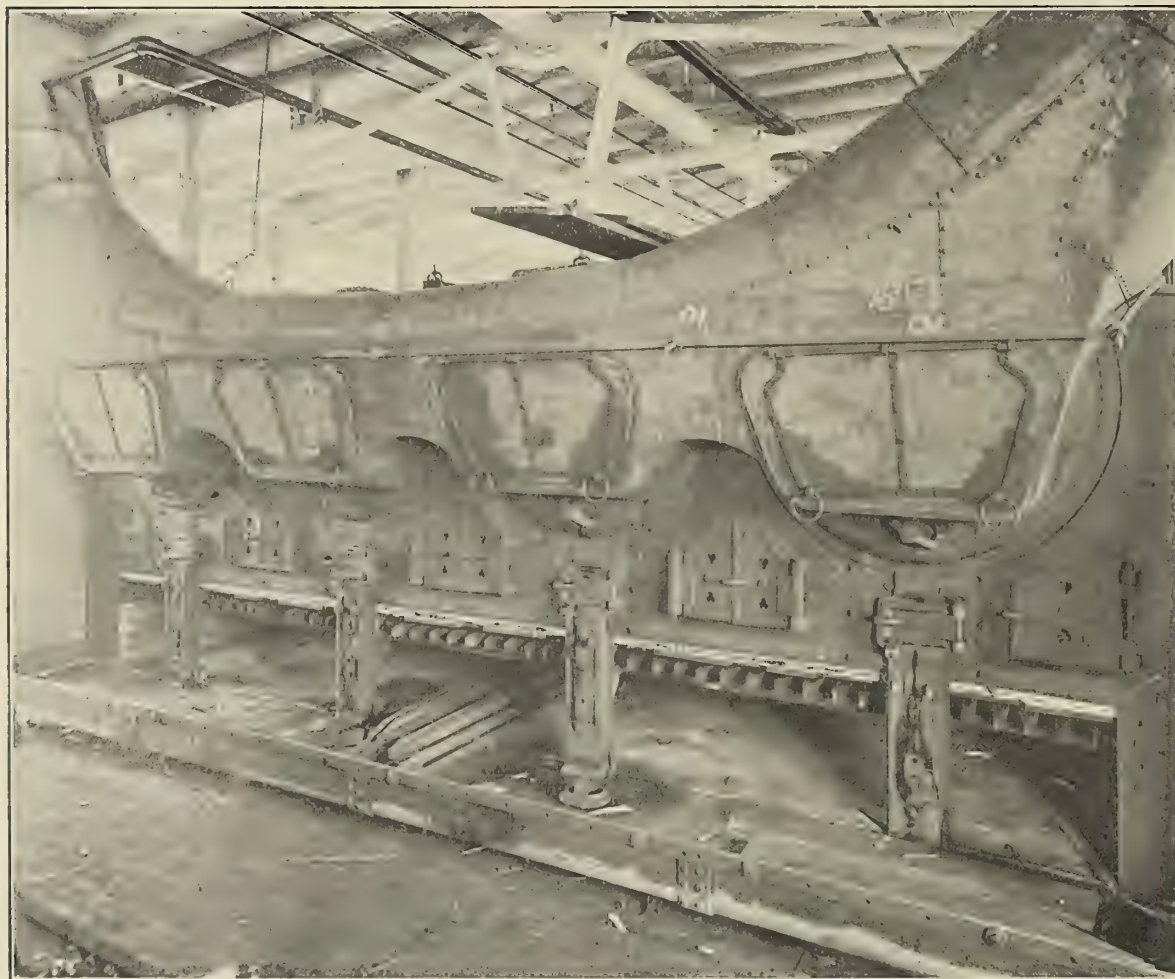
hurricane and texas. The main deck, except for the boilers forward and the engine room aft, is left open and free for carrying freight. The main saloon and passenger accommodations are on the boiler deck, while the officers' quarters and "Freedman's Bureau," or negro quarters, are on the hurricane deck. Both of these decks extend nearly the entire length of the boat. The pilot house is located amidships on the texas. The entire superstructure is built as light as possible, consistent with strength, and, according to southern customs, is elaborately ornamented. Special attention was given in the design to providing comfort-

Extreme beam	50 feet 6 inches.
Mean draft (unloaded)	30 “
Depth, molded (at lowest point of sheer)	6 “ 3 “
Sheer forward	5 “ 6 “
“ aft	2 “

The contract for building the hull was sublet by James Rees & Sons to the American Bridge Company, of Ambridge, Pa. On account of the tendency of shallow draft boats of such excessive proportions of length to depth to hog, a system of hogging chains, consisting of steel rods $1\frac{3}{4}$ inches and 2 inches in



THE REAR END OF THE BATTERY OF BOILERS, SHOWING THE MUD DRUM.



THE UPTAKES FROM THE BATTERY OF FOUR BOILERS INTO THE TWO SMOKESTACKS.

diameter fastened to the hull at the bow and stern and supported amidships at the height of the texas by heavy steel tubes or struts, is installed on each side of the boat. These tubes are 10 inches in diameter and 1 inch thick, fitted with cast iron caps

tensile strength, varying from 12 to 15 pounds in weight. The frames are 3 by 4-inch angles, $\frac{3}{8}$ inch thick, throughout the forward part of the boat, and $\frac{5}{16}$ inch thick aft of the midship section. They are continuous the entire length, and are spaced

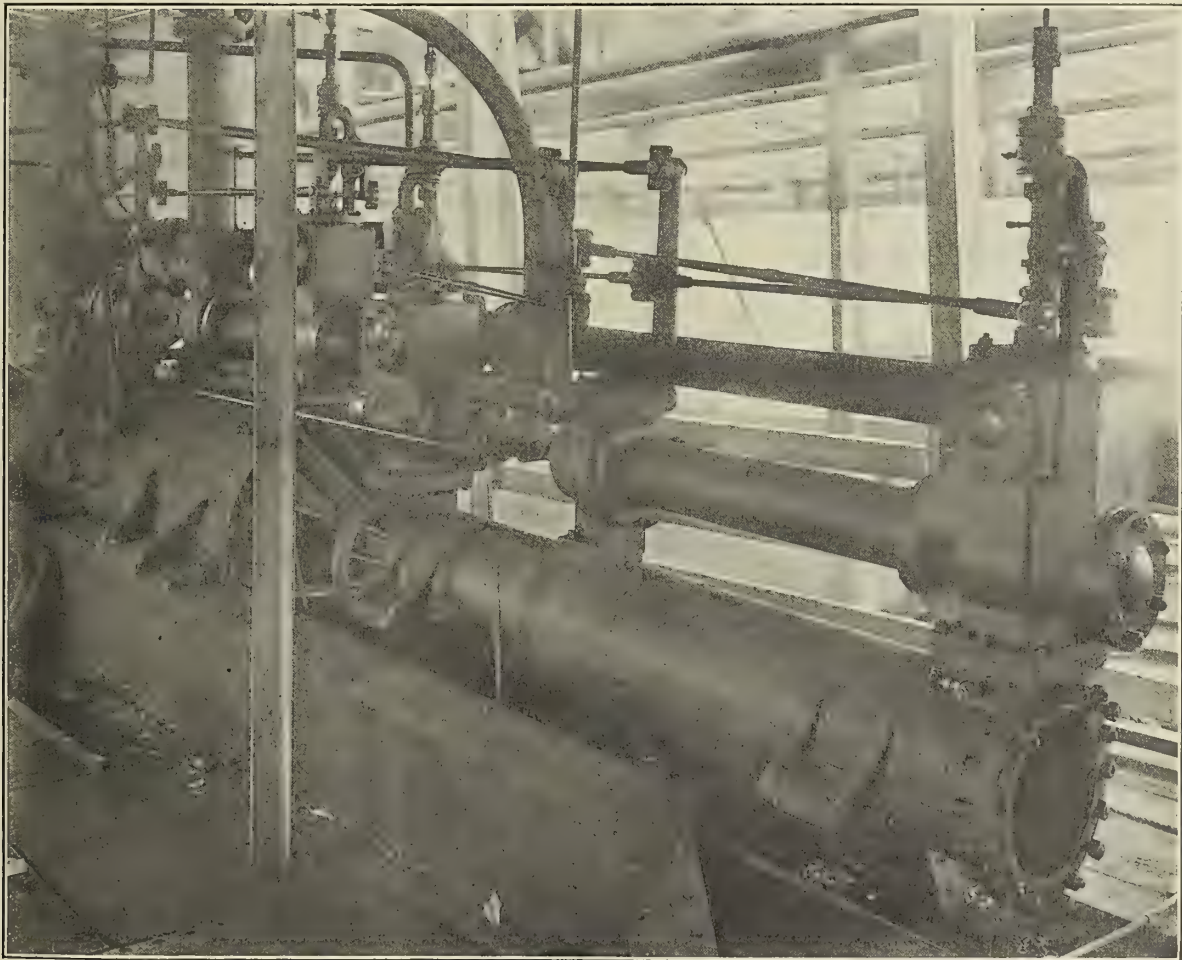


THE STEAMER S. S. BROWN ON THE ALLEGHENY RIVER, AT PITTSBURG.

and shoes. They rest on extra heavy keelsons in the bottom of the hold, composed of two channels 12 inches by 20½ pounds riveted 3 inches apart to the frames by angle clips. A 10-pound plate, 10 inches wide, is riveted to the top of the channels. They

18 inches between centers amidships, and 15 inches from the forward end of the boilers to the stem.

The hull is divided into twenty-one watertight compartments by three longitudinal and five transverse bulkheads, all of



THE PORT TANDEM COMPOUND ENGINE PARTIALLY ERECTED.

are located one on each side of the boat, 15 feet 5 inches from the center line, and are continuous from the forward end of the engines to the forward end of the boilers.

The shell plate is all mild open hearth steel of 60,000 pounds

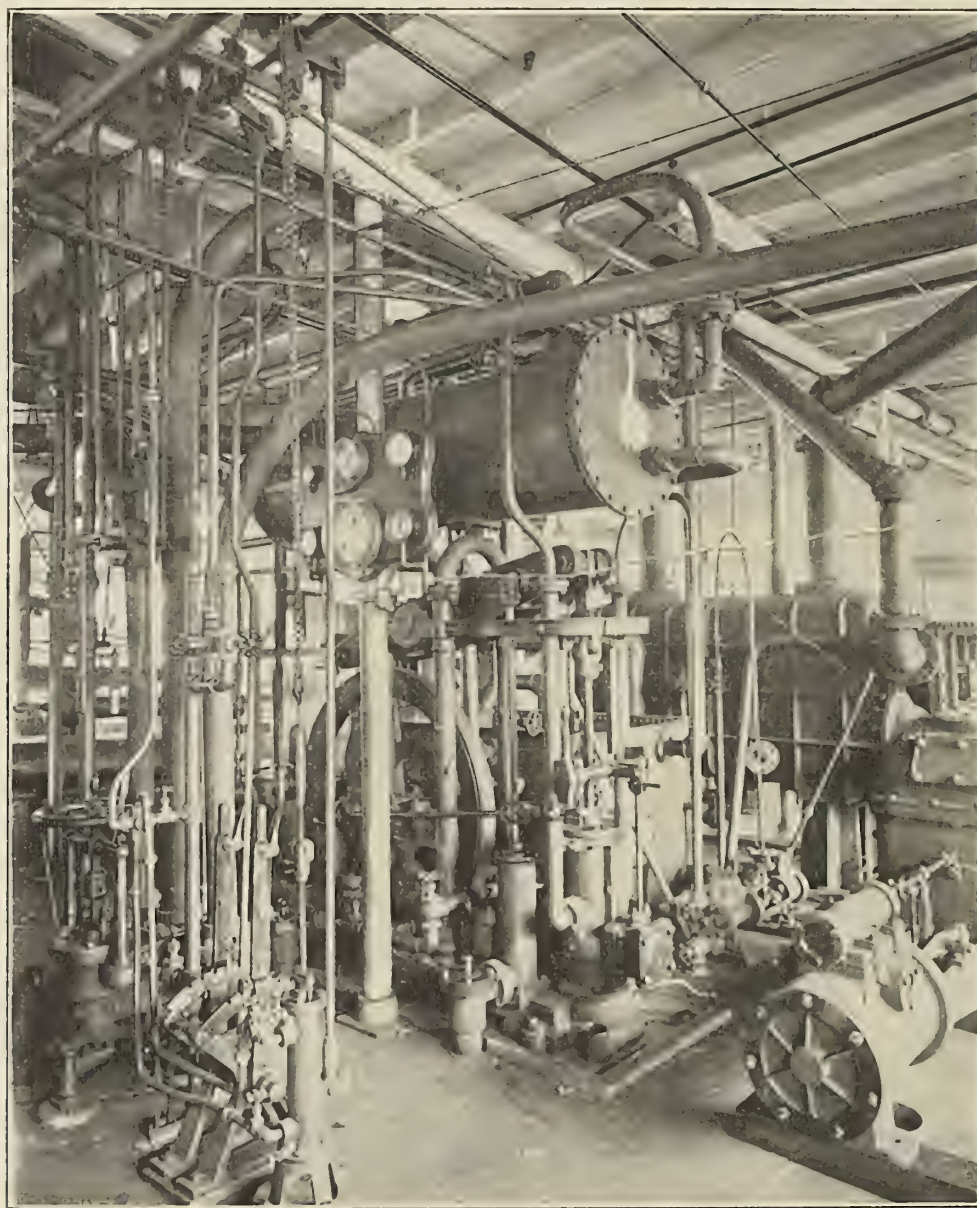
8-pound plate stiffened by vertical angles, $2\frac{3}{4}$ by $2\frac{3}{4}$ inches by $\frac{3}{8}$ inch. The stiffeners on the longitudinal bulkheads are spaced 3 feet apart, and the two outer bulkheads are further stiffened by the boiler deck stanchions, which are T-bars 4 by $4\frac{1}{2}$ inches

by 14 to 8 pounds, spaced 12 feet apart, and which extend through the main deck to the bottom of the hold, and are riveted to the bulkheads. The stiffeners on the transverse bulkheads are spaced 4 feet between centers. The longitudinal bulkheads are continuous their entire length.

Besides the three continuous longitudinal bulkheads and the two heavy keelsons on which the hog chain braces rest, longitudinal stiffness is further gained by eight Z-bar keelsons on the bottom and one on each side of the hull. These keelsons are Z-bars, 3 by 3 inches by 6 to 7 pounds, riveted by angle clips

guards by bracket plates to the shell plating. Such brackets offer considerable resistance to propulsion when, as is often the case, the boat is loaded nearly to the guards, and are liable to be torn away by snags in the river, necessitating frequent repairs.

There is a row of hold stanchions of $2\frac{1}{2}$ by $2\frac{1}{2}$ by 5-16-inch angles in the center of each hold, spaced 6 feet between centers. The boiler deck is supported by T-bar stanchions 4 by $4\frac{1}{2}$ inches by 14 to 8 pounds, over the outer longitudinal bulkheads; by 4-inch round stanchions over the center line bulkhead; and by wooden stanchions at the outer edge of the guards. Over the



THE DOCTOR, FEED HEATER, HOTWELL AND SURFACE CONDENSER.

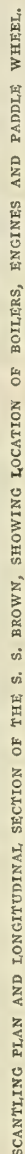
to the frames, and are made intercostal between the transverse bulkheads, although they are secured to the bulkheads at either end by bracket plates.

The main deck is plated with 10-pound steel throughout the engine room, and for a short space forward under the boilers. The entire deck is planked with $2\frac{3}{4}$ by 6-inch selected white pine. The guards, which extend out 3 feet 3 inches beyond the hull on each side, are of 15-pound plate, reinforced by a 15-pound doubling plate which extends out 15 inches from the side of the hull. The guards are further reinforced by heavy $3\frac{1}{2}$ by 6-inch angles at the outer edge, and $3\frac{1}{2}$ by $3\frac{1}{2}$ -inch angles securing them to the shell plating. This form of construction was designed to take the place of the older method of supporting the

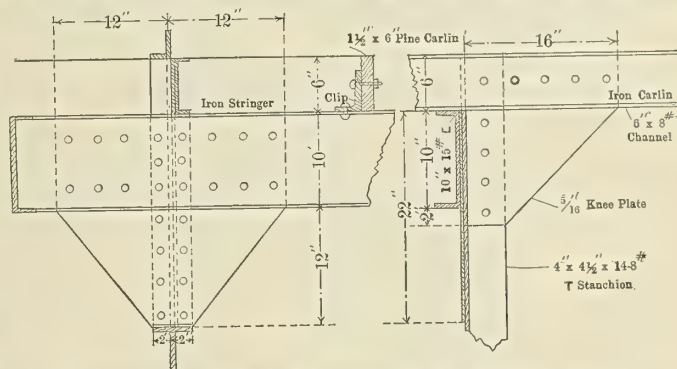
boilers a light framing of angles in the form of a truss is used in place of the round stanchions.

In the bow, two breast hooks of 15-pound plate 12 inches wide, fastened to the frames and shell plating by 3 by 5-inch angles, extend aft to the forward collision bulkhead. Solid floors 18 inches high, with reverse frames, are placed on every frame in this compartment.

The engine supports consist of two girders of a built-up I-section, spaced 47 inches apart. The web is of 20-pound plate with double $3\frac{1}{2}$ by 5 by $\frac{3}{8}$ -inch angles at the top and bottom. On top of each girder is a 25-pound cover plate 11 inches wide. These girders are riveted to the main deck, and extend out from the stern to support the wheel. The stresses set up in this

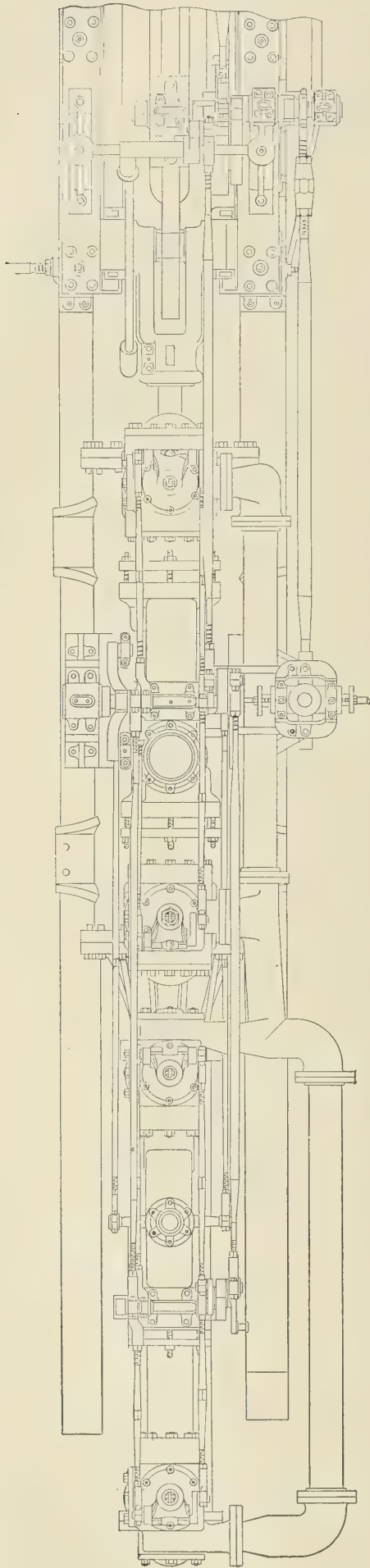


In the forward end of the saloon on the starboard side are the offices and opposite on the port side is the bar. Both office and bar are finished in Mexican cedar. On the port side over the forward end of the engine room is located the pantry. Directly below this, in the forward part of the engine room, is the galley. Opposite the pantry in the starboard side is the barber shop, and below that on the main deck is the men's toilet room. The engine room, galley, etc., are sheathed with iron as a protection against fire. At the after end of the boiler deck is a ladies' parlor. Throughout the main saloon the panel work

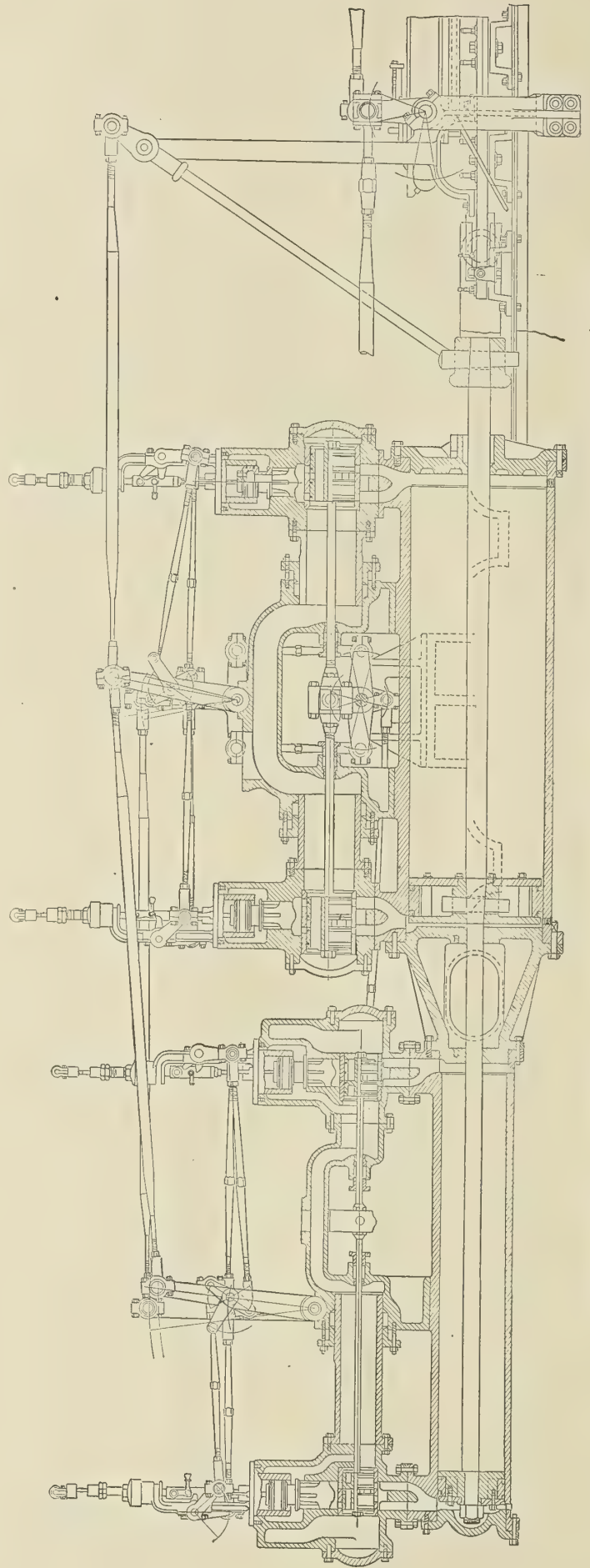


BRACING AT TOP OF SIDE STANCHIONS, UNDER UPPER DECK.

The boat is steered by four balanced rudders placed just forward of the wheel. The rudders are connected to two tillers, which in turn are connected to a steam steering gear built by the Wm. Johnson Co., of Cincinnati, Ohio. This gear consists of a single cast iron cylinder about 10 feet in length, containing a piston whose rod is connected through a short link to the tillers. The cylinder is placed athwartships. Steam is controlled by a four-way valve in the engine room, operated by wire ropes



PLAN VIEW OF ONE OF THE TWO TANDEM COMPOUND ENGINES, SHOWING ARRANGEMENT OF STEAM PIPING AND VALVE GEAR.



LONGITUDINAL SECTION THROUGH ENGINE, SHOWING THE LONG STROKE AND THE ELABORATE MECHANISM FOR OPERATING THE POPPET VALVES.

from the pilot house. The usual means is provided for steering by hand in cases of emergency.

BOILERS.

Steam is generated by four boilers of the western river tubular type, each 44 inches in diameter and 24 feet long. They are arranged in one battery, with a common steam drum across the top; and two mud drums, one at each end, across the bottom. A light iron casing is built around the boilers, extending just above the flues in order to direct the gases from the furnaces at the forward end back underneath the boilers to the return flues. This casing is lined with $\frac{1}{4}$ inch of asbestos, upon which the fire bricks are set. There is a cast iron furnace front, which, in addition to the fire doors, is provided with poker hole doors for stoking the fires. The boiler shells are of steel of 65,000 pounds tensile strength, 0.28 inch thick. The working steam pressure allowed by the United States inspectors is 165 pounds per square inch. There are six flues in each boiler. The three upper ones are 10 inches in diameter, and the lower ones 8 inches in diameter. The total grate area for the four boilers is 70 square feet; the total heating surface is 2,130 square feet; the ratio of heating surface to grate area is 30.4 to 1.

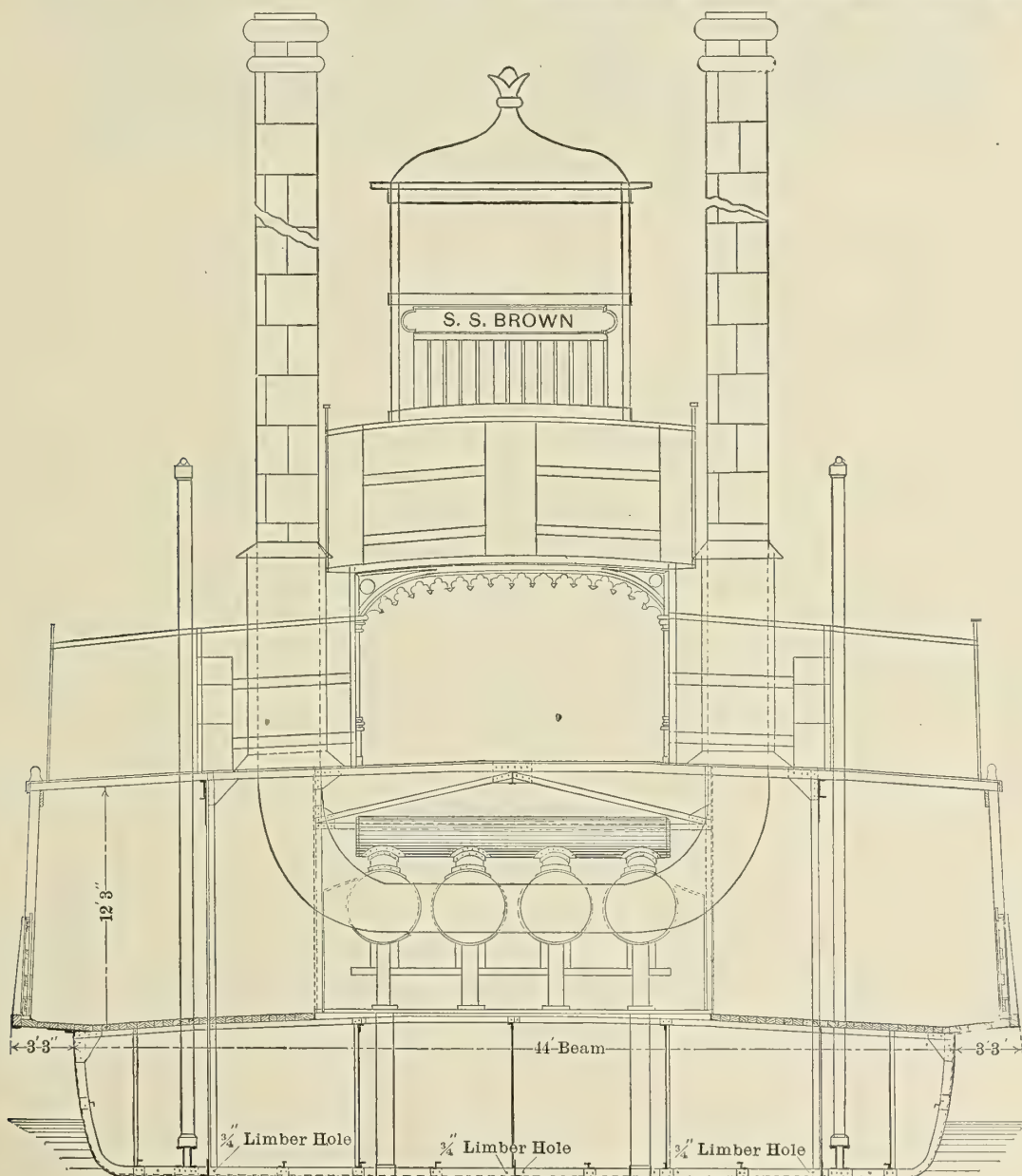
There are two steel stacks, each 3 feet in diameter and 60 feet high, above the grates. There is one stack on each side of the boat. Ordinary natural draft is used, but in cases of emergency forced draft can be obtained by means of steam blowers in each flue.

The auxiliary boiler is a vertical, submerged, tubular boiler 48 inches in diameter and 8 feet high. The shell is $\frac{3}{8}$ inch thick, and it will carry a pressure of 150 pounds per square inch.

The coaling arrangements on the *S. S. Brown* are exceptionally good. The regular supply of coal is carried in the holds. There are two large hatches leading to these holds, just forward of the furnaces. Each hatch is fitted with an elevator, so that the boilers may be fired directly from the elevator boxes. An additional supply of coal may also be carried on the main deck.

MAIN ENGINES.

The power for propelling the boat is developed by two slightly inclined tandem compound condensing engines, one on either side of the boat. The high-pressure cylinders are $15\frac{1}{2}$ inches, and the low-pressure 32 inches in diameter. The stroke is 8 feet. The two cranks are set at 90 degrees, and the engines are designed to run at about twenty revolutions per minute. Both cylinders are provided with piston valves and poppet cut-off



TRANSVERSE SECTION OF THE STEAMER IN WAY OF BOILERS, SHOWING THE EXTREMELY SHALLOW DRAFT.

vertical pump plungers. Two of these plungers are at each end of the beam, one on either side. The two pumps on one side are suction pumps, and draw the water from the hot well into the cold water column on one side of the pump, and thence into the feed water heater on top. The two pumps on the other side are force pumps, and force the water from the heater into the boiler feed pipe. The suction pumps are 5 inches in diameter,

is also supplied with exhaust steam from the auxiliaries, thus forming an additional feed water heater.

The Circulating Pump.—This is a 12 by 17 by 18-inch direct acting simplex Epping & Carpenter pump.

The Air Pump.—This is a 10 by 17 by 18-inch direct acting simplex Epping & Carpenter pump. In both the air and circulating pumps the rods and stuffing boxes are of composition.

The Fire Pump.—This is a 4 by $5\frac{1}{4}$ by 10-inch duplex pump, having pipes to the boiler and hurricane decks on both front and starboard sides of the boat, also on the main deck. The attachments are so arranged that a 50-foot section of hose will enable the crew to reach any section of the boat.

ELECTRIC PLANT.

Electricity for lighting purposes is generated by a $17\frac{1}{2}$ -kilowatt direct current Triumph generator, direct connected to a vertical double 5 by 4-inch Sturtevant engine, controlled by an automatic governor. The generating set, together with a switch board, is placed in the engine room. About two hundred and fifty incandescent lamps are fitted throughout the boat, besides four arc lights for use at the landings. Two 6,000-candle-power Carlisle & Finch searchlights, with dispersion lenses, are placed at the forward end of the hurricane deck, and are controlled from the pilot house.

COLD STORAGE ON BOARD SHIP.

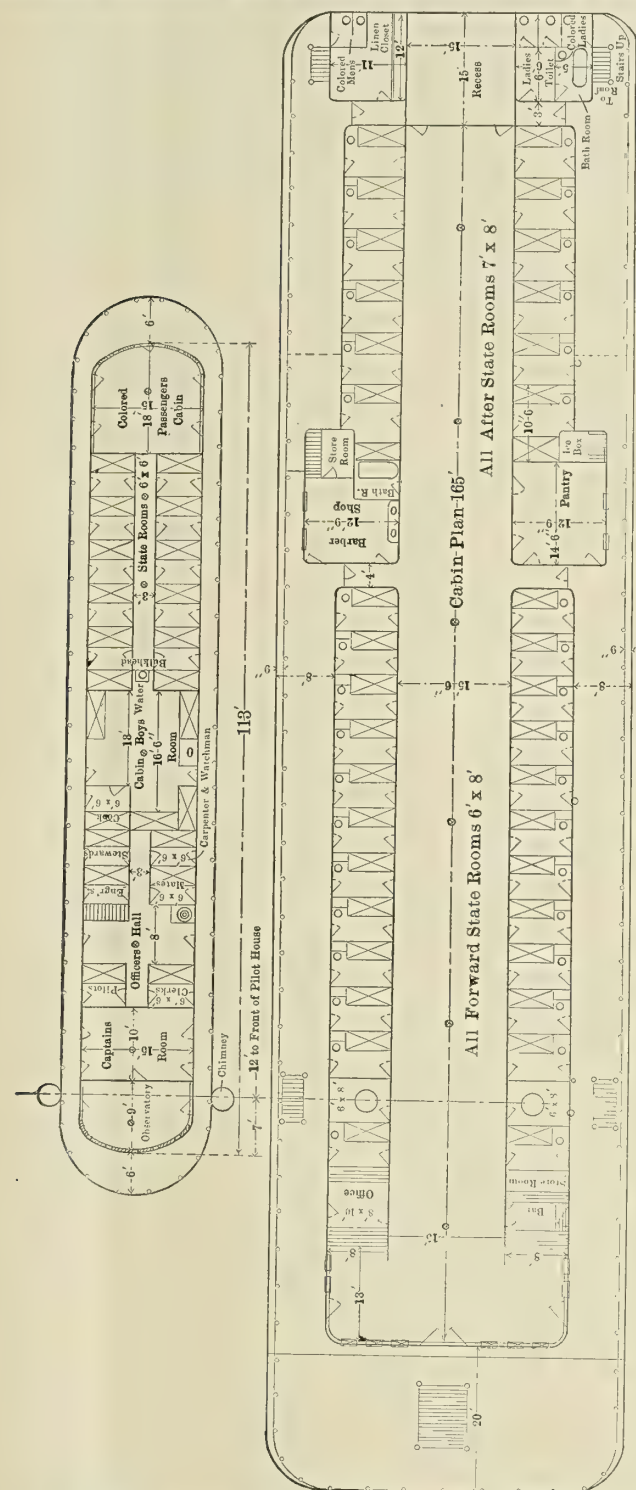
PART XI.

BY SYDNEY F. WALKER, M. I. E. E.

FAULTS IN AN ABSORPTION PLANT.

A large portion of the instructions given in connection with faults in a compression plant apply also to an absorption plant, because, as explained in the earlier part of the articles, the condenser, evaporator, brine circulation and air circulation are common to both compression and absorption plants, but the absorption plant has faults peculiar to itself. In it the generator with its accessories, the analyser and rectifier, represents the compression side of the compressor, and the absorber represents the suction side. It will be remembered that the ammonia is driven off from the aqueous solution in which it is carried in the generator, by the aid of heat, that it then passes through the analyser and the rectifier to the condenser, where it becomes liquid, and from the condenser takes the same path as with a compression plant, through the expansion valve and the expansion coils, coming back to the absorber instead of to the compressor. The high-pressure side of the plant therefore will consist of the generator, the analyser, the rectifier, and the condenser, while the low-pressure side will consist of the expansion coils and the absorber. Pressure gages are fixed at any convenient spot on the high-pressure side. In the form that is most in use in the United Kingdom, that made by Messrs. Ransomes & Rapier, the gage is placed on the rectifier, the gage registering low pressure being placed on the absorber.

Practically the same rules hold good as with the compression plant, viz., "watch the gages," but in addition to the pressure gages mentioned, there are also, in the absorption plant, two very useful glass liquid gages, one on the generator and one on the absorber, showing the height of the liquid in these vessels. Messrs. Ransomes also fix a liquid gage on the condenser, but there is no reason that a liquid gage should not be fixed upon all condensers. Where there is a receiver between the condenser and the expansion valve, it is always usual to have a liquid gage, showing the height of the liquid in the receiver. It will be remembered also that the continuous working of the apparatus is maintained by the continual exchange of weak and strong liquid, between the generator and the absorber. Weak liquid, as already explained, has a higher specific gravity than strong liquid, and as the gas is driven off from the solution in the generator, the weak liquid sinks to the bottom. In Messrs.



PLAN OF THE MAIN CABIN AND OF THE TEXAS OF THE ARKANSAS RIVER PACKET COMPANY'S STEAMER S. BROWN.

and the force pumps $4\frac{1}{4}$ inches in diameter. The heater consists of a cast iron shell supplied with exhaust steam from the auxiliaries, and contains a brass worm or coil through which the feed water passes. The worm consists of only a few turns of pipe of large diameter.

The auxiliary supply is obtained by an Epping & Carpenter (Pittsburg, Pa.) duplex feed pump 9 by 5 by 10 inches.

The feed pipe is of brass encased in a galvanized tube, which

Ransomes' plant the weak liquid is forced by the pressure of the gas in the generator towards the absorber, passing through the apparatus called the exchanger, on its way. In the absorber, on the other hand, the continual passage of the gas from the expansion coils into the liquid present in the absorber vessel, constantly increases the strength of the liquid, from the ammonia point of view, and the strong liquid is carried back to the generator, passing on its way through the exchanger, by the aid of a small pump provided for the purpose.

In Messrs. Ransomes' apparatus there is an automatic float valve, consisting of a vessel ellipsoidal in shape, in which there is a port opening to a pipe leading to the exchanger, and thence to the generator. As the absorber becomes charged with weak liquid from the generator on the one hand, and with ammonia from the expansion coils on the other, the height of the liquid gradually increases, its strength also increasing, and at a certain height it overflows into the vessel containing the automatic valve. In this vessel is a float controlling the valve and when a certain quantity of the strong liquid has passed into the valve vessel, the float rises, opens the valve leading to the exchanger, and allows the pump to deliver the strong liquid to the exchanger and the generator.

There is the same difference between the pressures on the high-pressure and low pressure side of the expansion valve as in the compression system, the pressures ranging as in that system, on the condenser side, from 135 pounds to 200 pounds per square inch, while the pressure on the evaporator and absorber side is usually in the neighborhood of 15 pounds per square inch. Both vary, however, as in the compression system, with the conditions ruling. On the condenser side the pressure increases with the temperature of the circulating water of the condenser. Messrs. Ransomes give a list in their instructions, stating that with cooling water at 50 degrees F. inlet, and 95 degrees F. outlet, the condenser pressure will be 135 pounds; with water at 60 degrees F. inlet the pressure rises to 150 pounds, and so on up to water at 90 degrees F. inlet, 115 degrees F. outlet, when the condenser pressure is 200 pounds.

In addition to this, the pressure of the steam employed in driving the ammonia out of the cylinder in the generator varies with the temperature of the condensing water. In other words, the temperature and the quantity of heat it is necessary to deliver to the ammonia solution in the generator increases as the temperature of the condenser cooling water increases. Messrs. Ransomes give the following figures: With cooling water at 50 degrees F. inlet, and condenser pressure of 135 pounds per square inch, steam at 40 pounds gage pressure is required, the temperature of the steam being about 287 degrees F. With cooling water at 60 degrees F. inlet, and the condenser pressure at 150 pounds, the steam required is at 45 pounds gage pressure, its temperature being about 292 degrees F. With water at 90 degrees F. inlet, and condenser pressure at 200 pounds per square inch, steam at 60 pounds gage pressure is required, its temperature being about 307 degrees F.

As in the compression system, the condenser pressure is ruled by the temperature of the condenser cooling water, and the pressure of the steam, or the temperature of the steam employed to drive off the ammonia, depends upon the condenser pressure. As with the compression system, anything which interferes with the cooling of the condenser increases the condenser pressure, and increases the pressure of steam required, while on the other hand, anything, such as cooling water of a lower temperature, which enables a lower condenser pressure to be carried, enables also a lower steam pressure to be employed, and practically is more economical. As also in the compression system, the pressure in the absorber depends upon the temperature to which the brine or the air to be cooled is reduced, the same rule applying as with the compression system. As in the compression system also, the higher the pressure in the absorber, the less work the steam in the generator has to do.

The points to be looked to principally in the absorption system, apart from those mentioned in previous portions of the article, as to the deposit upon condenser and evaporator pipes, etc., are that proper circulation between the absorber and the generator shall be continually carried on. If the ammonia pump does not deliver the proper quantity of strong liquid into the generator from the absorber, the quantity of ammonia present, it is evident, will be less than is required for working at the given steam pressure, and consequently the condenser pressure will fall, and the condensation of the liquid will be interfered with. There is also the same trouble in the absorption system from shortage of ammonia. In the absorption system, there is not only the possibility of ammonia leaking out through defective joints, as in the compression system, but there is also the possibility of its leaking into either of the vessels through which it passes. In any case, whatever the cause of leakage, shortage of ammonia leads to the same results as with the compression system, to inefficiency of the plant as a whole.

Imperfect condensation may also lead to the passage of ammonia gas, with the ammonia liquid, through the expansion valve, and the same results as explained in connection with the compression system. But with the absorption system, properly gaged, the engineer has always a guide in front of him. When the liquid in the condenser is not above a height which prevents gas from passing into the expansion coils, when the expansion valve is open, then the expansion valve must be kept partially closed. Again, the glass gages on the generator and absorber will show him the condition of the liquids in these vessels. To a certain extent, they show the quantity of liquid in each, which is of great importance, and the gage upon the condenser will show the quantity of liquid ammonia being formed.

There is the same trouble also in the absorption system from air getting into the system, and, being practically incompressible, setting up pressures opposing the actual working pressures. In the absorption system the result of the presence of air in the system, or of any other insoluble gas, such as hydrogen in the case of the decomposition of ammonia, is an increase in the pressure on the absorber gage on the low-pressure side of the system. As in the compression system, therefore, a constant watch upon the gages will give early warning that something is wrong, and further examination will show what it is.

If there is air in the system, it is discovered, and expulsion is obtained by the same means as in the compression system. There is a valve specially arranged, on the absorber, for the purpose of getting rid of the air. An India rubber tube is attached to this valve, its other end being immersed in a vessel containing water. When the valve is open, the air is driven out, and may be seen bubbling up through the water; and when all the air that can be got out at the moment has passed, the water will commence to smell strongly of ammonia, and the valve is then closed. It is necessary in some cases to repeat the operation several times before all the air is got rid of, as it lurks in pockets in the pipes, etc., and only gradually finds its way to the point of exit.

It will be noted that the absorption system is free from the troubles mentioned in connection with the compression system, arising from the presence of oil. Except from gross carelessness, there should be no oil in the system at all. Hence the troubles that were mentioned, of oil being carried over as vapor, and being decomposed into its constituents, and deposited upon the inside of condenser and expansion pipes, are absent. On the other hand, the guide offered by the temperature of the delivery pipe of the compressor is also absent, but the glass gages mentioned offer a very much better and more certain substitute.

COLD CHAMBERS IN COLD STORAGE TRAMP STEAMERS.

The arrangement of cold chambers, or cold holds, in the steamer that is constantly taking one class of produce, has

already been fully described, but the case of the tramp steamer, making more or less of a specialty of carrying produce in cold atmospheres, presents certain difficulties. Where the produce carried is always the same (say always chilled beef, or always bananas), the holds can be fitted either with brine pipes, or with cold air circulation, and there is no difficulty about the matter. But it is the essence of the tramp steamer, that it takes any

When chilled meat is being carried, or frozen meat, the whole of the brine pipes, overhead and at the sides, are put into operation, and the hinged boards and hinged port-holes are all arranged wide open. The cooling effect is produced directly by the brine pipes, assisted slightly by a certain amount of air circulation. When fruit or dairy produce, or anything that requires only cold air circulation, is carried, the overhead brine

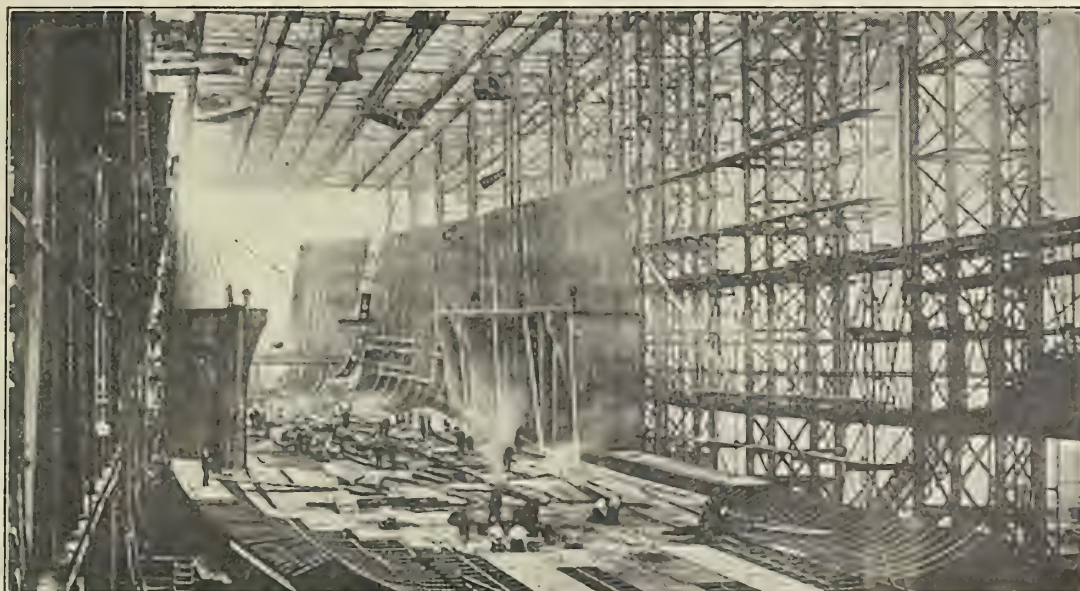


COVERED BUILDING SLIPS IN THE WEST YARD OF SWAN, HUNTER & WIGHAM RICHARDSON, AT WALLSEND.

cargo that offers, and it may happen that on one voyage it has to take chilled beef, and on another voyage fruit, dairy products, or other produce requiring cold air.

To meet these requirements, a somewhat novel arrangement has been worked out by a Liverpool engineer. He provides brine circulating pipes overhead, and at the sides of the holds, and it is arranged that each of the pipes can be individually shut off. In addition, the pipes on the sides of the holds are provided with wood screens made of matched board, having hinged flaps

pipes are not put into operation, the side brine pipes alone being operated, and to the extent that may be necessary to produce the required temperature. The air is cooled by driving it through a duct arranged for the purpose, over the side brine pipes, out into the hold, and back by another duct, the air being kept in motion by means of a fan placed at any convenient position between the outgoing and return ducts. It is stated that this arrangement has given great satisfaction, and overcomes the difficulties mentioned above.



THE FORWARD SIDE AND BOTTOM FRAMING OF THE MAURETANIA IN PROGRESS AT WALLSEND.

at the top and the bottom, and also, in certain cases, having alternate boards hinged. He further provides hinged port-holes in the fixed boards of the screen. The use of these arrangements is to provide a cold air circulation, or a complete brine cooled atmosphere, with the same plant, without any appreciable alteration to the holds, and without the necessity of the air cooling arrangement that is commonly employed.

SWAN, HUNTER & WIGHAM RICHARDSON, LIMITED.

In 1842 the first iron vessel ever built on the Tyne was launched from the site of the present south yard of the Neptune Works, at Walker. In 1860 the Neptune Works were founded by Mr. John Wigham Richardson, who had acquired the four acres then comprising the property. There was a frontage of 320 feet, and the longest of the three berths was likewise 320



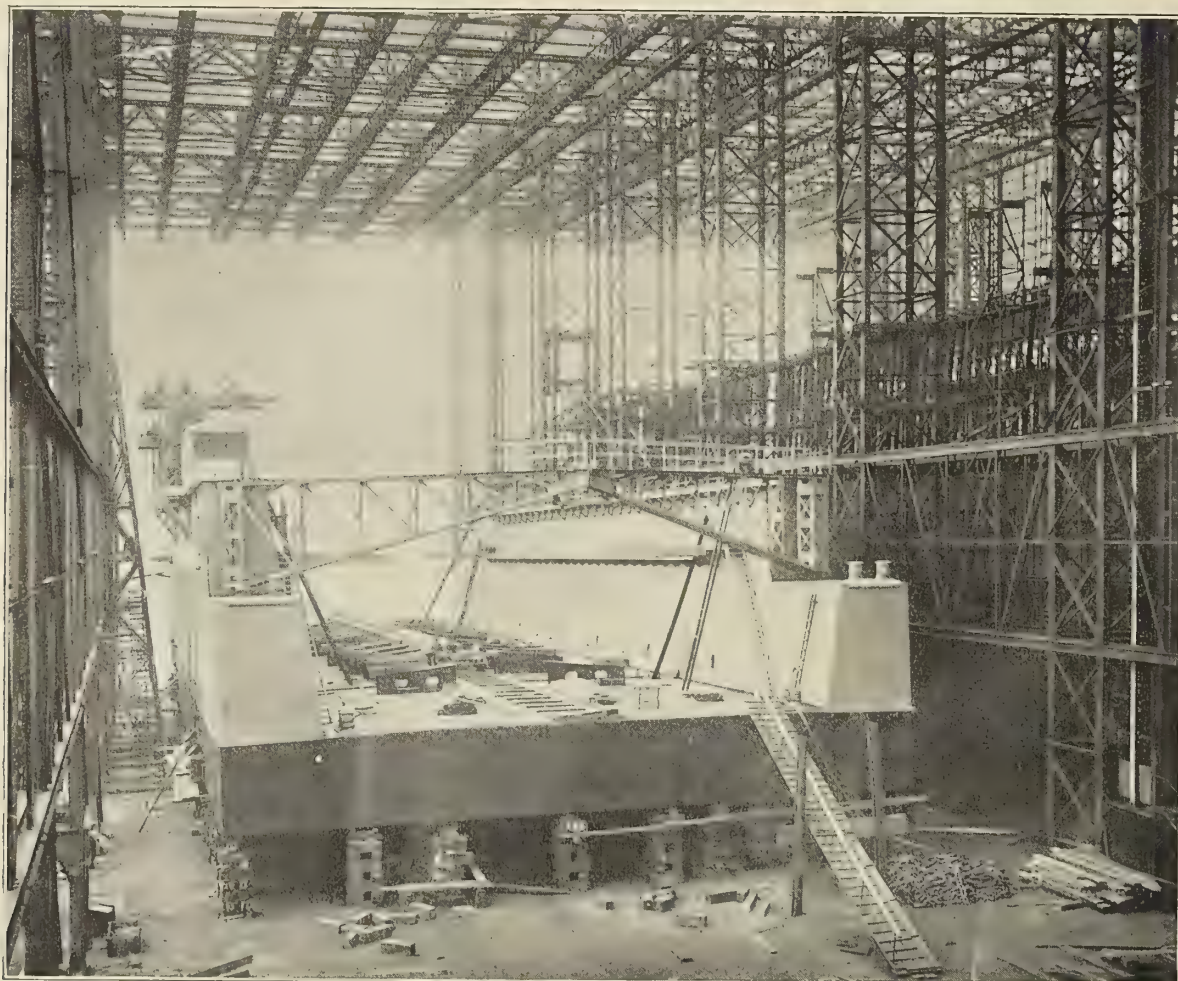
GENERAL VIEW OF WALLSEND SHIPYARD OF SWAN, HUNTER & WIGHAM RICHARDSON; HAWTHORNE, LESLIE & COMPANY IN FOREGROUND.

feet. The maximum annual output of ships was about 4,000 tons, two hundred men being employed. The present company is an amalgamation formed in 1903 between the original Neptune Works, which included also marine engine works and a boiler shop, C. S. Swan & Hunter, Ltd., whose Wallsend shipyard and floating dock date from 1872; and the Tyne Pontoons & Dry Dock Company, Ltd., founded in 1882 for dry-docking and repairing ships. The premises of these three firms were contiguous, and the total area now comprised within the works is 78 acres, with a river frontage of about 4,000 feet.

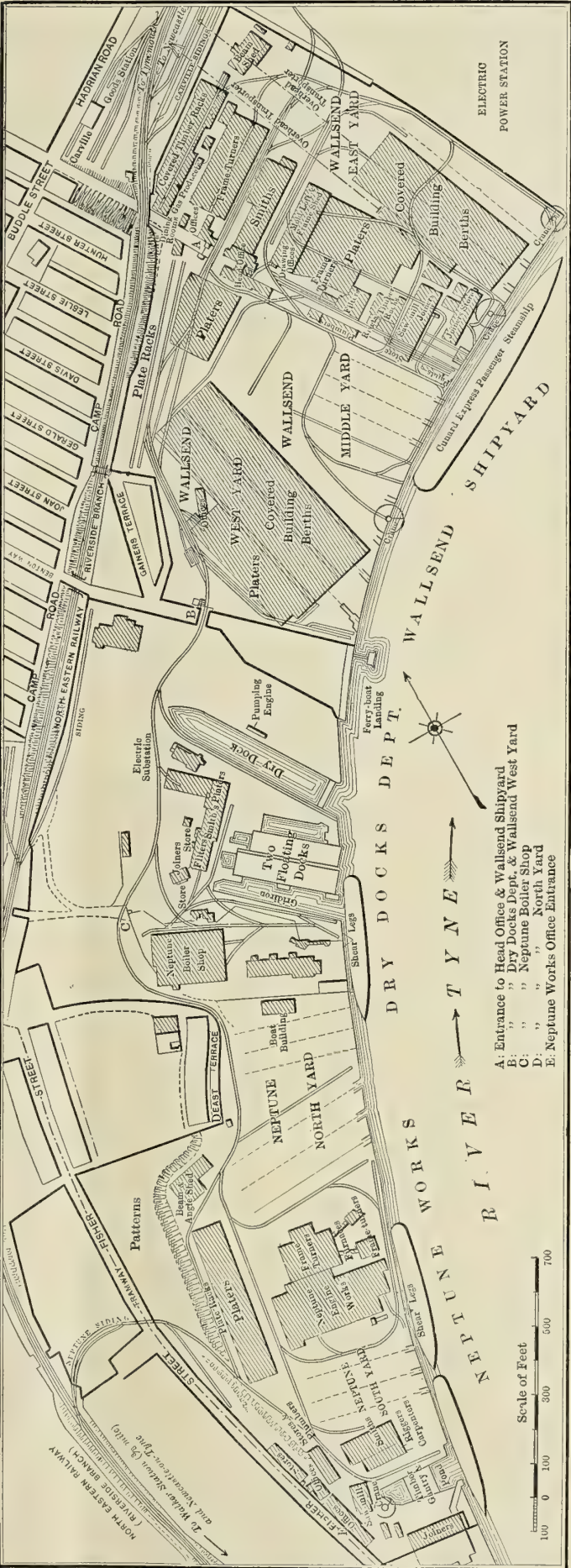
The equipment includes a dry-dock with a length of 550 feet,

an entrance width of 76 feet, and a depth of water over the sill of $26\frac{1}{2}$ feet; and two floating docks, capable of lifting vessels up to a length of 350 feet. A large amount of noteworthy repair work has been done in this department, including lengthening of vessels, etc.

The capacity of the yard is very considerable, the output in 1900 having been 42,880 tons; in 1901, 49,087; in 1902, 64,220 tons; in 1903, 66,452 tons; in 1904, 73,592 tons; this being within less than 100 tons of the largest amount of construction of any concern for that year; in 1905, twenty-two vessels aggregating 82,727 tons, or an average of 3,760; and in 1906, twenty-five ships



A FLOATING DRY-DOCK READY FOR LAUNCHING FROM THE YARD OF SWAN, HUNTER & WIGHAM RICHARDSON.



PLAN OF THE SHIPYARDS OF SWAN, HUNTER & WIGHAM RICHARDSON.

of 126,921 gross tons, or an average of 5,077. The tonnage in 1905 was third in the world, and in 1906 it was first, including, as it did, the new Cunarder *Mauretania*. The vessels built include Atlantic liners, mail and passenger steamers, channel and coasting vessels of high speed, paddle wheel steamers, private yachts, cargo liners, tramp steamers, cable steamers, train ferries, oil-carrying vessels, sailing ships, floating docks, as well as a great variety of special constructions of all sorts. The engines installed have been of both the reciprocating type and turbines.

The largest steamers so far completed are the Cunard liners *Ivernia* and *Carpathia*, each of about 14,000 gross tons. There has recently been launched, however, the Cunarder *Mauretania*, of 33,200 tons, which, with her sister ship, *Lusitania*, form the largest vessels so far constructed in the world.

Electric equipment for driving the machinery and for lighting the works has been installed, while hydraulic power is extensively used in all departments for lifting heavy weights and for riveting. There is also a large pneumatic plant for riveting, chipping, drilling and calking. Overhead traveling electric cranes are fitted in the four large glass-covered building berths, the largest of these berths being 740 feet long, with a clear width of 100 feet and a height of 140 feet. These berths are also well lighted by electricity to enable them to be used in dark weather, and a great advantage of the covering is that work can be carried on without interruption in all sorts of weather. Besides the covered building berths, there are twelve others, making a total of sixteen.

The furnaces for heating the angle bars and other shapes used for ship's plating are heated by producer gas so distributed as to insure a uniform heat along the entire length.

The engine works are capable of turning out each year about 50,000 horsepower, and work in collaboration with the Wallsend Slipway & Engineering Company, Ltd., in which the shipbuilding concern has an interest. This establishment is situated on the Tyne about half a mile east of the shipyard, and covers an area of 51 acres. The equipment comprises large engine and boiler works, foundry, a dry-dock 544 feet long, and two slipways for hauling out ships up to 3,000 tons gross. The quay accommodation is especially large, because of the fact that the establishment lies at the junction of a tributary stream, the water frontage being about 1,000 feet on each river. At these works the machinery and boilers for the *Mauretania* have been constructed.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of March 11, 1907, the following percentage of completion of vessels building for the United States Navy:

BATTLESHIPS.				Feb. 1	Mar. 1
	Tons	Knots			
Nebraska	14,948	19	Moran Brothers Co.	98.78	99.
Kansas	16,000	18	New York Shipbuilding Co..	97.4	98.
Mississippi	13,000	17	Wm. Cramp & Sons.	71.72	76.25
Idaho	13,000	17	Wm. Cramp & Sons.	67.87	69.77
New Hampshire	16,000	18	New York Shipbuilding Co..	61.8	63.5
South Carolina.	16,000	18½	Wm. Cramp & Sons.	6.32	7.74
Michigan	16,000	18½	New York Shipbuilding Co..	5.9	8.29
ARMORED CRUISERS.					
California	13,680	22	Union Iron Works.	97.8	98.8
South Dakota.	13,680	22	Union Iron Works.	95.2	95.9
North Carolina.	14,500	22	Newport News Co.	71.56	73.28
Montana	14,500	22	Newport News Co.	66.05	68.26
SCOUT CRUISERS.					
Chester	3,750	24	Bath Iron Works.	64.18	67.79
Birmingham ...	3,750	24	Fore River Shipbuilding Co.	59.	64.1
Salem	3,750	24	Fore River Shipbuilding Co.	59.2	64.2
SUBMARINE TORPEDO BOATS.					
Cuttlefish.	—	—	Fore River Shipbuilding Co.	91.	91.
Viper.	—	—	Fore River Shipbuilding Co.	89.1	89.1
Tarantula.	—	—	Fore River Shipbuilding Co.	92.5	92.5
Octopus.	—	—	Fore River Shipbuilding Co.	88.5	88.9

The Institution of Naval Architects.

The March session of the Institution was of unusual interest, mainly on account of the excellent papers read and discussed. These papers were fourteen in number, as follows:

The Influence of Machinery on the Gun Power of the Modern Warship. By James McKechnie.

Safe Submarines and the Future of the Art. By Simon Lake.

On Some Points of Interest in the Construction and Launch of the Lusitania. By W. J. Luke.

The Evolution of the Modern Cargo Steamer. By S. J. P. Thearle.

Cranes for Shipbuilding Berths. By C. Piaggio.

Torsimeters as Applied to the Measurement of Power in Turbine and Reciprocating Engines. By Archibald Denny.

Torque of Propeller Shafting: Some Conjectures, Investigations, and Results. By J. H. Gibson.

Propeller Struts. By G. Simpson.

Experiments with Dr. Schlick's Gyroscopic Steadying Apparatus. By Sir William H. White.

Approximate Formulae for Determining the Resistance of Ships. By A. W. Johns.

The Application of the Integrator to Ship Calculations. By J. G. Johnstone.

The Prevention of Fire at Sea. By Professor Vivian B. Lewes.

Modern Floating Docks. By Lyonel Clark.

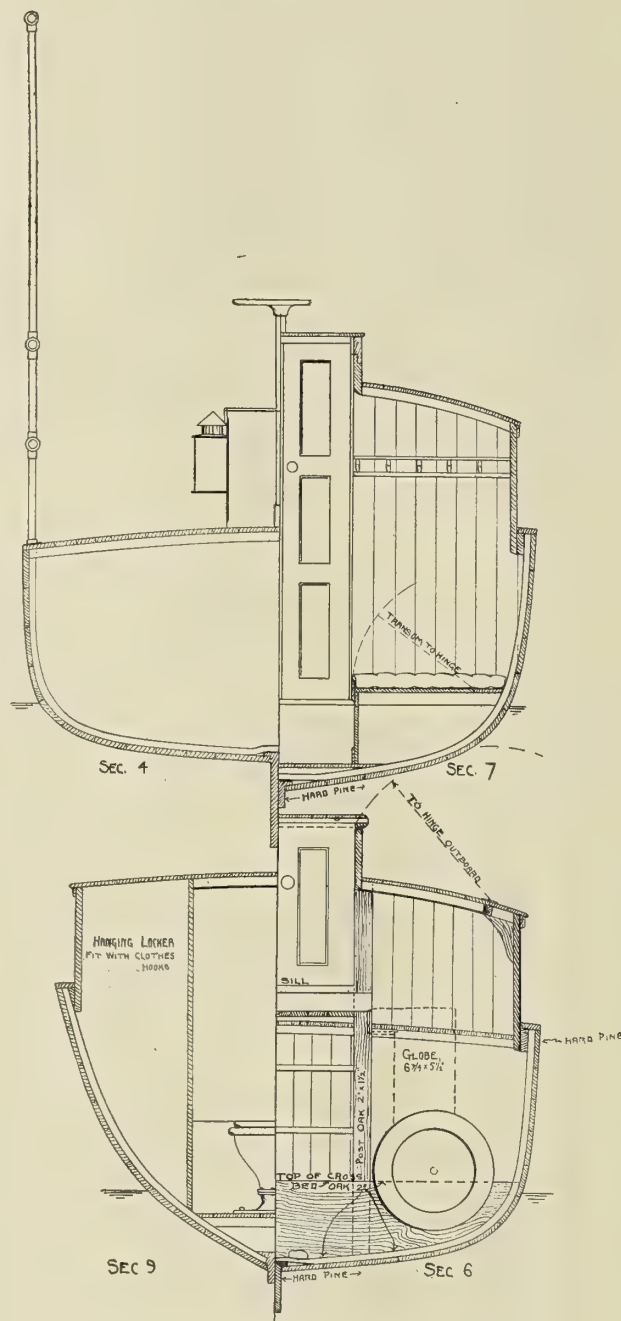
Some Phases of the Fuel Question. By Professor Vivian B. Lewes.

Some of the papers will be found in this number. Others will follow next month.

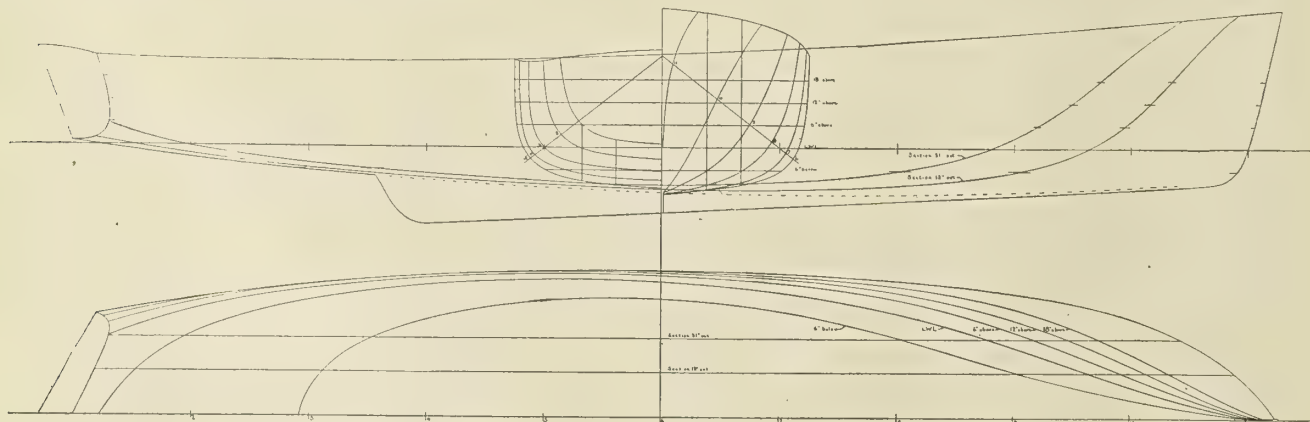
A Twenty-Eight Foot Motor Boat.

The launch illustrated was built a year ago by Messrs. Stearns & McKay, Marblehead, Mass., for the Carnegie Institution of Washington, and has since been duplicated a number of times. The boat has a length of 28 feet over all with a beam of 6 feet 6 inches and a maximum draft of 2 feet. The design combines great seaworthiness, a fair speed and complete reliability. The lines shown indicate good stability, and the flare at the bow with a sharp waterline should conduce to dryness and easy motion. The stern has been broadened out to give excellent deck room, but it will be seen that it is rounded on the bottom to avoid the pounding which would accompany a flat stern.

For a launch of this size the cabin is very roomy, and is fitted with a lifting hatch, giving a clear head room of 6 feet 6 inches. The deck aft has been carried entirely across, leaving no cockpit. This is due to the fact that the launch was designed for very severe service, and it was necessary to adopt some such measure to avoid all possibility of swamping.

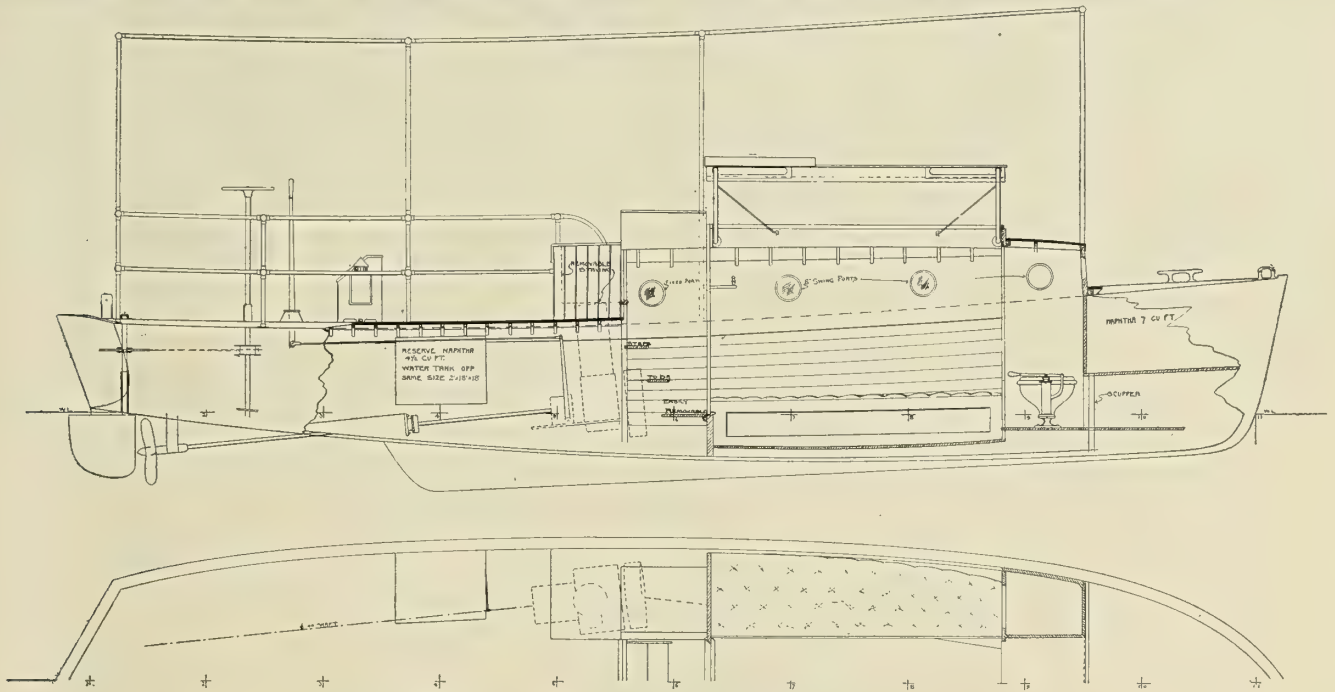


FOUR TYPICAL TRANSVERSE SECTIONS OF THE BOAT.



The propelling machinery consists of two single cylinder Globe engines, developing together about 10 horsepower. This gave a speed somewhat in excess of nine miles per hour. The engines have cylinders $6\frac{3}{4}$ inches in diameter with a stroke of

separately or together on the same switchboard. The boat is of the hunting cabin type, and was designed for the use of the Institution in connection with its marine research and biological laboratory on Loggerhead Key, Dry Tortugas.



INBOARD PROFILE AND ACCOMMODATION PLAN OF THE TWENTY-FOOT BOAT.

$5\frac{1}{2}$ inches, and each is fitted with a flywheel. The shafts, as will be seen from the illustration, have a considerable dip, and in addition to this they converge toward each other at the stern. This arrangement was adopted to enable the engines to be placed as far into the wings as possible, in order to permit a passageway to run between them.

An awning is fitted, and the boat is handled entirely from a

A Forty-Eight Foot Motor Boat.

One of the most prominent of the exhibits at the recent Motor Boat Show in New York was a 40-foot "Elco-de-luxe" motor boat fitted up in sumptuous style, and propelled by a six-cylinder engine of 100 horsepower at a speed of about twenty miles per hour. From this as a basis has been built up a somewhat larger boat on the same lines, which we illustrate here-



THE FORTY-FOOT PROTOTYPE OF THE FORTY-EIGHT-FOOT ELCO-DE-LUXE.

position near the stern where a steering wheel with vertical axis, and lever for operating the reversing gear of the engine, are fitted. The cabin is equipped with lockers, toilet, ice box and two extension transoms, while a switchboard on the port side takes care of the storage batteries, dynamo, sparking and lighting system, and is so arranged that the engines may be run

with. A number of these larger boats have already been sold, and the type is expected to be very popular.

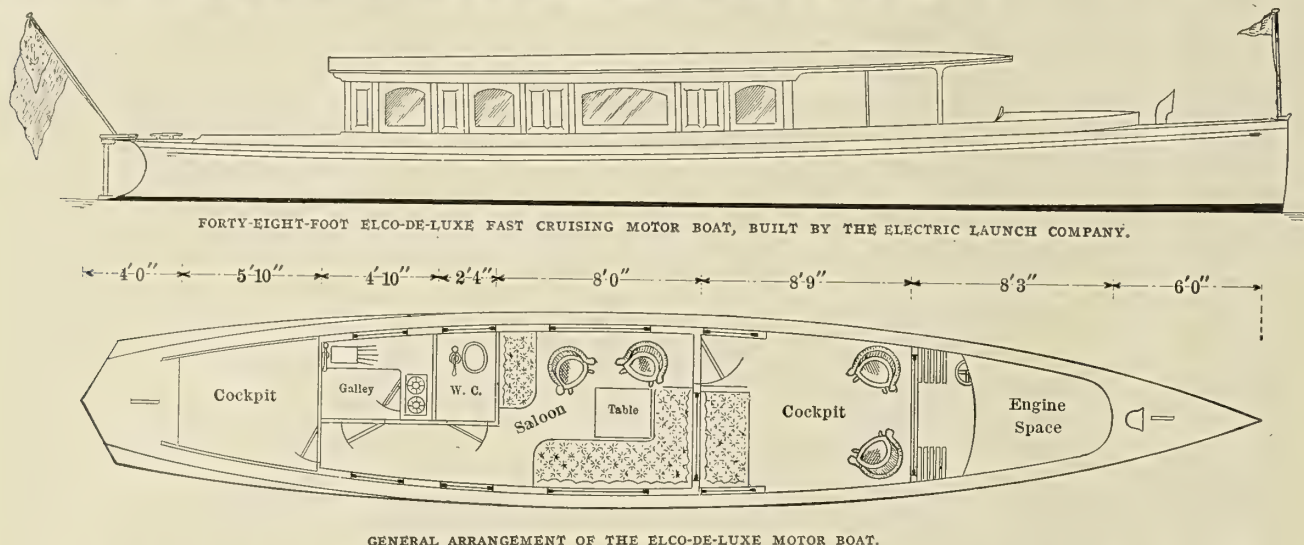
The length of the boat, as shown in the drawing, is 48 feet, being made up of a 6-foot forward deck, a space 8 feet 3 inches devoted to the helmsman, with a turtleback protection over the engine in front of him; a saloon, 8 feet 9 inches long,

opened partly at the sides; a closed saloon, 8 feet long; a passageway of 7 feet 2 inches flanking the toilet room and galley; an after cockpit of 5 feet 10 inches; and an after deck of 4 feet. The beam is 8 feet and the draft 3 feet.

The hull is constructed of oak frames and selected cedar planking, intercostal pieces of ash being screwed over all seams between frames. The planking is fastened to the frames by copper nails, riveted throughout, and the hull is painted white above the waterline and copper green below. The decks and inside and outside of cabin are all of mahogany. Large windows have been provided in the cabin.

The entire engine cockpit is lined up in brass in the interests of easy cleaning. Just aft of the engine are located the controller levers, alongside the steering wheel, the whole being

While the boat has extremely comfortable cabin accommodations, the passengers being all situated well forward, with a clear observation of the course ahead, the question of speed has not been neglected, the boat being designed, as above stated, for about twenty miles per hour. The type is said to be especially adapted for lakes and rivers, where country residences are located at some distance from stations or steamboat landings, and where it is desired to make a trip of eight or ten miles in the shortest possible time. The protection afforded to the passengers is such as to make it possible to use this boat in stormy weather, and at all seasons of the year. The boat was built by the Electric Launch Company of Bayonne, N. J., while the engine is a product of the Standard Motor Construction Company of Jersey City, N. J.



so arranged that one man can operate the entire outfit. The engine is started and reversed by compressed air. The cylinders measure 6 inches in diameter by $6\frac{1}{2}$ inches stroke, and are supported upon turned steel stanchions. The compressed air is furnished by an independent pump attached to the engine. The turning of a small lever admits air under pressure into three of the cylinders, starting the engine in motion. The gasoline is then turned on, and, by means of the electric ignition, the engine begins to function on its regular fuel. There is an ignition reverse, intended for use in varying the speed. Ignition is provided for by means of a low-tension magneto and storage batteries, and is of the usual standard make-and-break type. An independent dynamo, driven by the engine, furnishes current for charging the batteries used in lighting the entire boat.

The partially opened cockpit saloon forward is very roomy, admitting the use of wicker chairs and observation seat. A glass wind-shield in front, which may be dropped into a mahogany pocket when not in service, keeps off flying spray and rain. The side curtains, attached to the roof of the cockpit, may be rolled up out of sight when desired. The observation seat, which has a locker beneath, is upholstered in pigskin.

The inclosed cabin immediately aft of the open cabin is fitted up with a combination of permanent seats and wicker chairs. There is a mahogany table, buffet and cupboard for china and glass. The upholstery is of Flemish velvet; the windows are of special plate glass, and are very large. They are all equipped with sash balances, enabling them to be easily raised or lowered. The window curtains are of silk. A portière shuts off the passageway leading aft on the starboard side; handsome electric fixtures are fitted. The galley is arranged for heating and cooking by electricity, the water used being drawn from special tanks used for this purpose. It contains an ice box, water cooler and sink. The after cockpit is used for carrying luggage, and for the handling of lines, etc.

Steamboating on the Mississippi.

BY FREDERICK D. HERBERT.

As characteristic and typical as the prairie "schooner" was on the plains in the early days of emigration to our great west, so has been the river steamboat to the great system of inland navigation on the rivers of the Mississippi valley. For many years the whistle of the steamer "around the bend" was the signal for all hands on the plantation to run to the landing to get the mail, and news from up or down the river. Up to within a few years of the civil war the steamboat and river were the only means of quick communication with the outside world. A map of the Mississippi valley shows how completely that great area, from the gulf on the south to the lakes on the north, and from the Appalachians to the foot hills of the Rockies, is covered by the lines of rivers, great and small, all eventually discharging into the Mississippi. Shoals and sand bars were the rule, so that at any but the highest stages of water navigation of boats of any size seemed impossible. However, high freights on very valuable cargoes awaited those who could carry them to the seacoast, so it is no wonder that the early boat builders quickly developed a special type of large, fast, shallow draft steamboat, that could navigate in very shoal waters; in fact it was said of some of the boats that they would "float on a heavy dew."

Thus the river boat played an important part in the development of the south, carrying supplies to plantations on the remotest tributaries, and on the down trips bringing the farm products to market. It was during the first high waters of the fall that the river men reaped their harvest. Every planter was anxious to get his cotton shipped first; and the high water allowed the captain to load his boat down with cotton until the bales in some cases were on a level with the windows of the "texas."

The fleet of river boats kept pace with the tremendous growth of the great valley. Several lines of fast passenger and express

packets were established between the prosperous river cities, all the way from New Orleans to Minneapolis, the head of navigation—a distance by river of over 2,200 miles, as well as on the Ohio, Missouri and Arkansas.

It was in the early "fifties" that the first railroads were built

senger and freight schedules offered by the railroads were sure to get the business. At about the time of the outbreak of the civil war, river traffic had already reached the top point, and the fight for freight cargoes was intense. Many stories are told as to how the formerly well-to-do captains (who were gen-

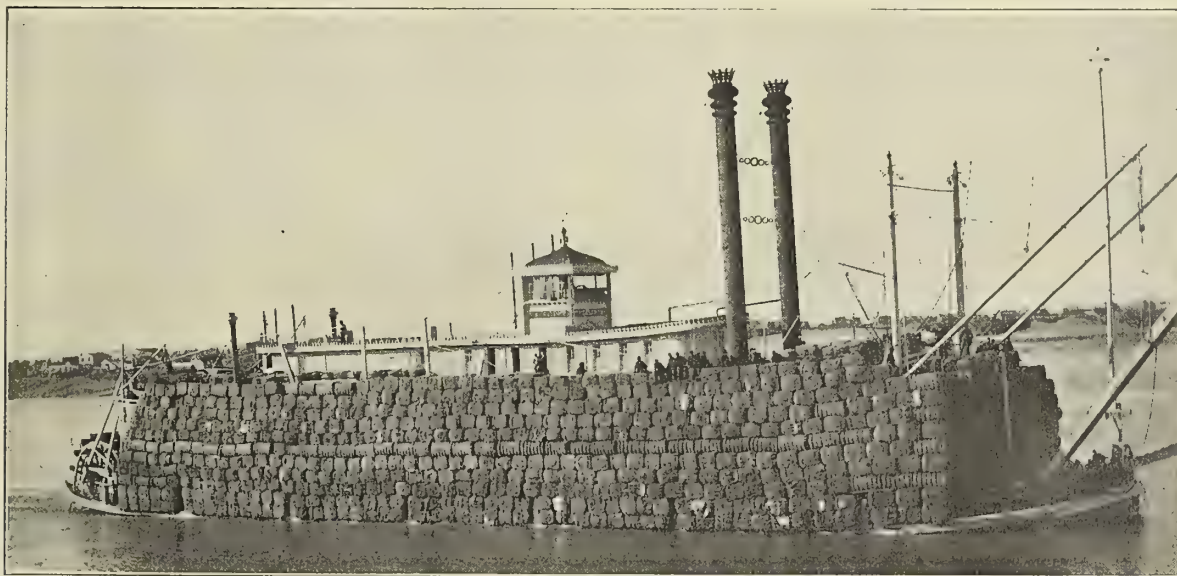


THE PASSENGER STEAMER QUINCY, OF THE DIAMOND JO LINE.

paralleling the river. At first the boatmen scoffed at these interlopers, but competition soon became keen, and then it was evident that the boat trade was doomed for the reason that it could not be depended upon for regular service. During the summer months some the smaller streams were unnavigable even to the lightest draft boat, while in a very dry season it was only by chance that the boats could navigate the larger rivers.

erally the owners) would run the river's length to pick up a cargo.

When war broke out, the control of the Mississippi river and its tributaries was at once recognized by both north and south as the key to the entire western campaign, and it was only after eighteen months of fighting, from Fort Donaldson and Shiloh, to Island No. 10 and Port Hudson, that Grant was finally suc-



COTTON-CARRYING STEAMER T. P. LEATHERS, WITH A RECORD CARGO OF COTTON—4,000 BALES.

In fact, the Mississippi river itself was at some points occasionally impassable. With continually shifting sand bars, and the current of the river cutting out new courses or filling in old ones, it took an expert pilot to feel his way up and down stream without stranding. Grounding his boat did not bring disgrace upon the captain; the boats were built for it, and it was to be expected at low water.

In comparison with this uncertain service, the regular pas-

cessful at Vicksburg. In all of these campaigns the river steamers played a most important part. With guns mounted behind bulwarks staved with several thicknesses of heavy planking, and with engines and boiler protected from a stray shot by extra lengths of boiler plating and coils of anchor chains, these boats served effectively as gunboats and transports, without the aid of which the western campaign might have dragged on for years.

Since the close of the war, the number of steamers on these rivers has gradually diminished; if compared with the enormous increase of total freight tonnage carried, the proportion falling to the boats is almost nothing. There is, however, one class of trade that is still open for the steamer—that is, the towing of coal down from the Pittsburg region. As has been described in these pages, big tows of barges loaded with coal are assembled on the Kanawha or Ohio, and taken down to New Orleans. The towing consists of pushing about twenty or thirty barges made fast to each other, four or five abreast, and five or six deep. The great, awkward looking, slow moving stern wheel steamer is peculiarly adapted to this work, and can quickly navigate the fleet around a sharp turn or past a shoal.



RAFTING STEAMER FRONTENAC TOWING LOGS.

On the head waters of the Mississippi may still be seen an occasional lumber raft in tow. This used to be frequently met with, but now the denuding of the northern forests takes the lumbermen to the Pacific coast.

When compared with the decided changes in design and construction through which general shipbuilding has undergone during the last fifty years, it is remarkable how closely the river boat of today resembles her ante-bellum forefathers. Improvements have been made in details of both hull and machinery—in some exceptional cases the hulls are of steel, and the engines are compounded and run condensing. However, the great majority of vessels of today follow closely the lines originally laid down. The hull is long and very shallow, about 35 or 40 midships depths to one length, and 6 or 7 depths to one beam. The floors run straight for about two-thirds the length amidships, and are fastened by heavy knees to the frames, which also have little form except at the bow. The deck beams have only moderate crown—thus the midship section is about rectangular. The sheer is frequently greater at the stern than at the bow, in order to carry the wheel frames high enough above the water level. Most of the stern wheelers have square sterns, with cutaway keel rising up almost to the waterline, the floors being without any dead rise at all. This gives good, solid water for the wheel to turn in. The bows are full.

The boats are fitted with two or more long, shallow rudders hung from the transom frame, and of such shape as to fit under the wheel. The tillers are all connected with one gear. The total steering surface is large, and so effectively placed that the boats are handy in maneuvering, even at slow speeds. On the cotton steamers, the guards are wider all around by the width of a bale of cotton than the sides of the vessel. When all available space on the main deck is stowed with cotton, the bales are lashed on the guard, one above the other, on both sides from stem to stern, and as high as the upper deck, with only the necessary passageways left clear.

The forecastle deck is the busiest part of the boat—landings are made bow on, and it is from this point that freight and pas-

sengers are received or discharged. The main deck is given up exclusively to machinery and freight. The engine is naturally at the stern, and to counterbalance this weight the boilers are placed well forward. To tie this long shallow hull together, and stiffen it up so that it can carry the heavy weight of boiler and engines at opposite ends, as well as carry the cargo, several heavy lattice longitudinal girders are worked in the hull from stem to stern; one of these is on the center line, and may be in the form of a longitudinal bulkhead, while on each side of it are one or two continuous girders tying the floors and bottom to the deck. A substantial galleys frame, on the line of a side keelson, ties the bow with the stern and the wheel frames. The upper deck is the passenger deck, containing staterooms, dining room, etc., while the top deck has the officers' staterooms or texas, with wheel house at the forward end, or on top.

The regular boiler equipment is two long flue boilers of small diameter, known as the Mississippi type. After many years of hard service these may be still considered the best for handling the muddy river water.

The engines run non-condensing, with a steam pressure of from 50 to 75 pounds. In the old stern wheelers, a high-pressure engine is on either side, connecting to the crank through a long pitman. The cranks are set quartering. The poppet steam and exhaust valves are mounted on top of the cylinders, and are driven through a system of levers from the crosshead of the opposite engine.

The side-wheelers have separate engines, and the wheels are independent of each other, *i. e.*, the shafts do not connect; thus the boats are easy to handle, as one engine may run ahead and the other astern. All the auxiliaries are combined in one pump,



GOVERNMENT STEAMER BARNARD, USED IN REMOVING OBSTRUCTIONS.

familiarly known as the "doctor." It is a steam-driven fly-wheel pump, to which are attached boiler-feed, fire and bilge pumps. This is the usual machinery equipment. Coal is cheap, and the boat owners claim that it does not pay to put in any improvements.

To a salt water sailor, the first sight of a big river steamer coming along at full speed, with volumes of thick smoke pouring from the crowned-like funnels, the heavy puffs of steam from the two high-pressure exhaust pipes, and the ponderous stern wheel raising a young waterfall on its buckets—this is a sight which in no way reminds him of a boat; and should the passing steamer be one of the popular excursion vessels, with her steam calliope playing, "jack tar" would be still further mystified as to how to classify her.

Nevertheless, these boats have eminently served their day; they were designed to meet certain exacting conditions of navigation and trade peculiar to the valley, and their success has never been questioned. That the water at certain times of the year should be too low to permit any vessel to navigate, or that,

because of the channel, the distance between two cities on the river bank should be two or three times what it is by train—these prime reasons, which have caused the decline of river traffic, are beyond the province of the boat builder to remedy.

To improve the waterways the government has spent and is spending annually millions of dollars in building levees and jetties to confine the river to a definite course, and in dredging away the shoals in the channel. This is a gigantic operation, yet very great permanent improvements have been accomplished. There are but two points on the river where rapids occur, these are passed through locks and canals. One is at Davenport, where the government arsenal is established, and the other is at Keokuk.

The method of warping a steamer over a shoal shows the ingenuity of the builder and crew. In former days this was a task that had to be done frequently. Every steamer of any size is equipped with the necessary rigging, and does not have to wait for assistance. The photographs of the *Quincy* in the Des Moines canal and of the *Gen. Barnard*, show the equipment of spars just forward of the cabin deck. When not in use, these

through another block attached to the main deck, and then taken to the capstan. A pull on this line has a tendency to raise the nose of the boat, or to throw her head to one side, depending on the angle to which the spar is set. When a good strain is on



SPAR BEING RESET FORWARD FOR PULLING BOAT OVER SAND BAR.



POSITION OF SPAR SHOWS THAT BOAT HAS BEEN PULLED AHEAD.

spars and derricks stand upright against the masts. The position of the spars on the *Gen. Barnard* indicates they have just been used, or are expected soon to be used.

When a boat gets aground, the first thing determined is the amount of water all around her; then the way in which she should be forced to go, that is, whether straight ahead or to the right or left, or whether she should be backed off and the channel tried in another place. If it is decided to pull her through the place where she is headed, generally a line is run out to shore, if a fastening can be found in the right direction. Then, with a strain on the line, which is taken around the capstan, and with the help of the wheels, the boat is soon afloat.

If this pull is not effective, or if a line cannot be run in the right direction, the spars which are the darker "sticks" in the *Barnard* picture, are used. These are lowered into the water, being held in upright position by block and line attached to the derricks—their companion "sticks" in the picture. A line is run through a block attached to the upper end of the spar, and

this spar, the line ashore is tightened, and the wheels are worked, and the boat goes; maybe not the first time, but she moves eventually.

The engravings showing a steamer aground clearly illustrate this way of getting her over the shoal. Ahead is the line leading ashore from the capstan; the derrick is shown at the center of the picture. In one view the lines are slackened for resetting the "stick" further forward; in the other the angle of the stick and the taut down-hauls and bow line show that the boat is moving ahead. In both of these views the gang plank, swinging from a center-line boom, is shown at the center of the picture, and is not to be confused with the spars. For these two views, and several others in this article, the writer is indebted to Capt. Fred Bill, who for many years has been well known on the river.



THE QUINCY IN A LOCK OF THE DES MOINES RAPIDS CANAL.

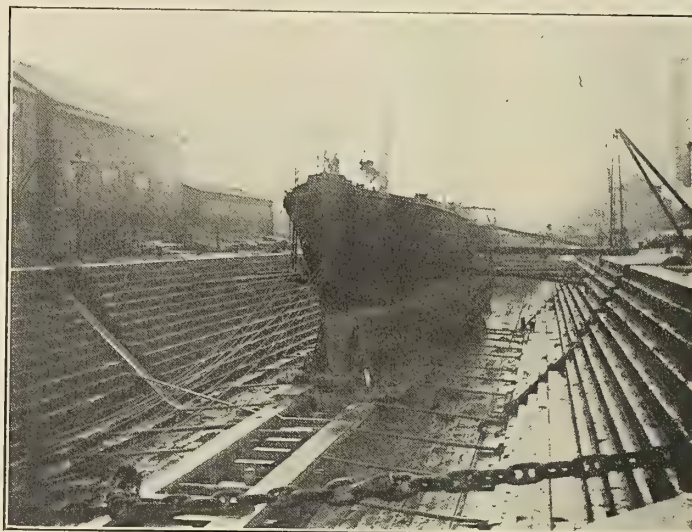
Below are given the dimensions of two modern steamers plying in the passenger service on the Mississippi, between St. Louis and Minneapolis. These vessels run on a fast schedule, which it is possible to maintain at all times, for at low water no freight at all is carried. This trip of 730 miles is one of the most diversified in point of scenic beauty that can be found in the world.

Passing up to the clear water above the junction of the yellow Missouri, the river winds between rugged stretches of cliffs and through foaming rapids to the broad quiet bays and prosperous cities and villages.

Truly the great river, with its 1,500 navigable branches draining one-half of the United States, is called the "Father of Waters," and if we follow the history of the early colonization and quick development of the great valley, we are bound to accord a place of front rank to the river-men among those who have aided in the prosperity of that country.

	<i>St. Paul.</i>	<i>Quincy.</i>
Length over all	280 feet 0 inches.	265 feet.
Beam molded	42 feet 1½ inches.	42 feet.
Beam over guards	72 feet 0 inches.	74 feet.
Depth, amidships	7 feet 0 inches.	7 feet.
Depth, forward	9 feet 4 inches.	9 feet.
Depth, aft	9 feet 6 inches.	9 feet.
Number of boilers	4	2
Type	Mississippi	Scotch*
Length	28 feet.	14 feet.
Diameter	44 inches.	84 inches.
Number of flues in each boiler.....	6	—
Number of tubes (3½ in. diameter) ..	—	142
Number of high-pressure engines..	2	2
Diameter of cylinders	22 inches.	22 inches.
Stroke	7 feet.	8 feet.
Valve gear	poppet valve.	poppet.
Diameter of wheel	28 feet.	28 feet.
Length of buckets	10 feet.	12 feet.
Number of buckets	18	17
Number of auxiliary engines.....	7	7

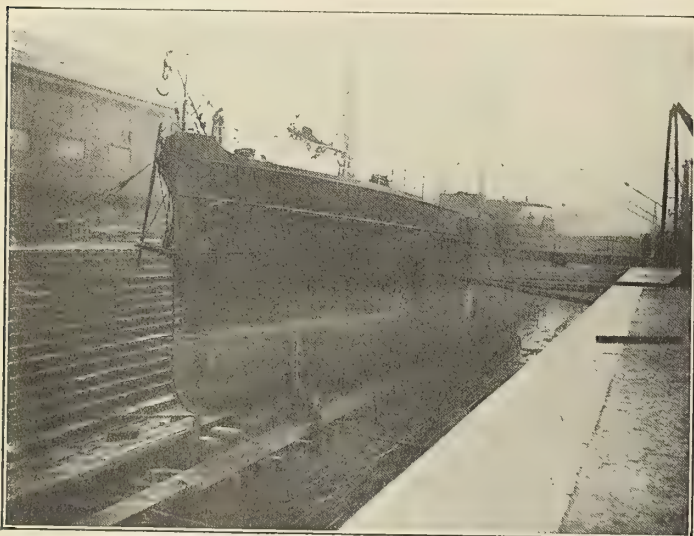
*With corrugated flues on the outside. The boiler sets on top of the corrugated flues.



THE WAYS AND TACKLE ARRANGED FOR THE OPERATION.

of improved design fitted. It is expected that, under ordinary conditions, the vessel's speed will be increased by about half a knot.

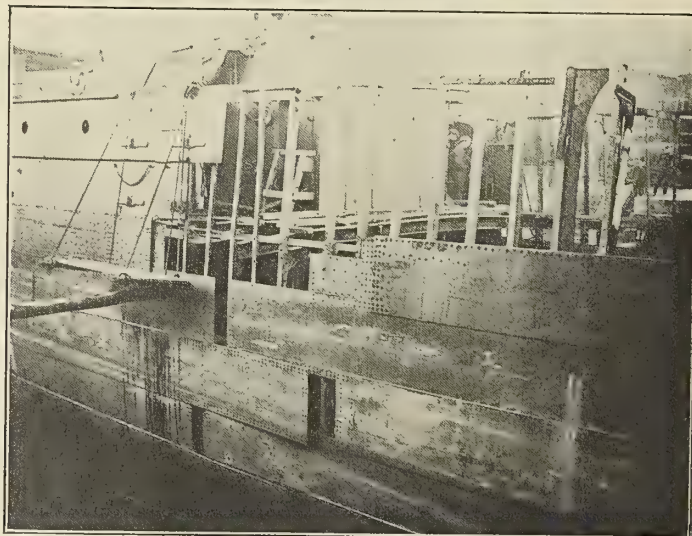
The new hull structure, which, for the most part, forms the boiler room, is on the ordinary floor principle, and this construction is carried into the new No. 3 hold, originally the boiler room. In Nos. 2 and 4 holds and in the engine room the vessel has a cellular double bottom for water ballast. The original coal bunkers are completely reconstructed, and new bunkers fitted at the fore end of the boiler room, abreast of the donkey boiler recess. The question of strength has been carefully considered, and those parts which will be subjected to greater stresses, owing to the increased length, have received special attention. The main sheer strake and the strake below are doubled for a considerable length amidships, and additional web



THE STEAMER THAMES, PLACED IN DRY-DOCK FOR LENGTHENING.

Lengthening of the Steamship Thames.

The success which attended the lengthening of the Carron Co.'s steamship *Forth* has induced that firm to carry out a similar alteration to her sister ship *Thames*, a vessel of 930 tons gross register, with a length of 230 feet, beam 31 feet and molded depth 16 feet 6 inches. It was decided to cut her amidships and increase the length to 279 feet 6 inches, an addition of 49 feet 6 inches, also to provide additional accommodation for first and second class passengers and crew. In addition to these important structural alterations, the owners decided to re-boiler the vessel with two double-ended boilers and a donkey

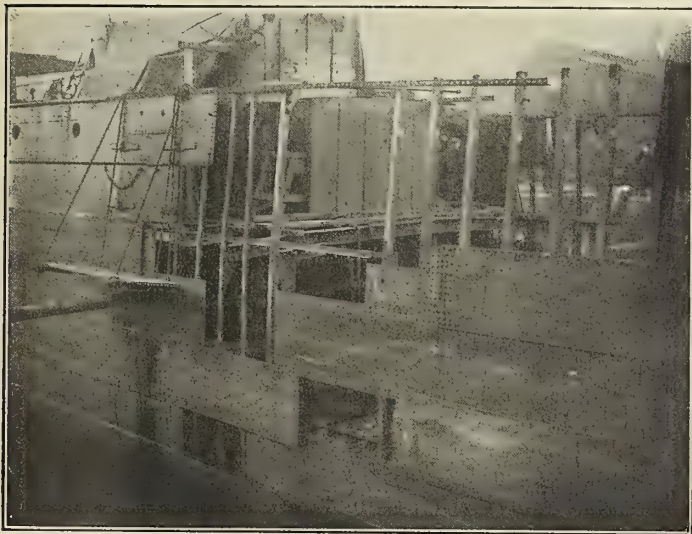


STARTING TO DRAW THE TWO ENDS OF THE SHIP APART.

frames fitted in the bridge space, and in way of the cargo doors.

The old first class saloon and state rooms, situated under the poop, form the new second class accommodation, for 56 passengers. The new first class accommodation for 72 passengers is constructed on the upper and bridge decks amidships. The first

class dining saloon is situated at the forward end of the bridge deck, and extends for the full breadth of the vessel. It is handsomely paneled in polished mahogany and tastefully upholstered, and fitted up with piano, electric radiators, etc. The first class smoking room and the captain's cabin will be on the boat deck, which is above the bridge deck houses, and part of this deck is

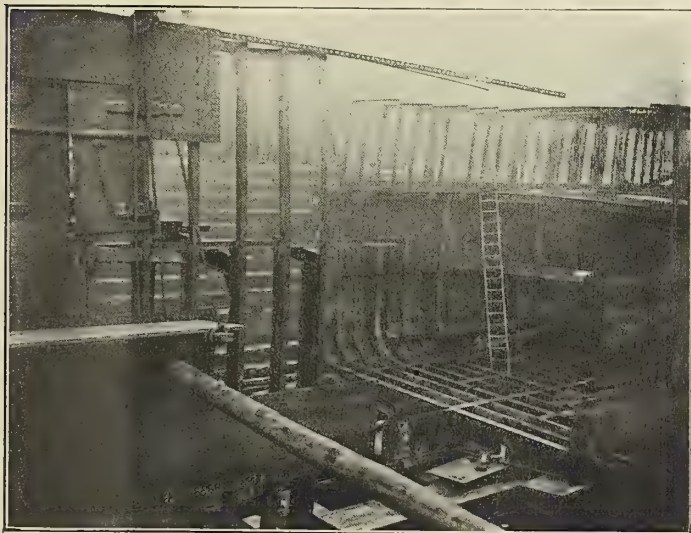


VIEW DURING THE PROCESS OF DRAWING THE ENDS APART.

to be reserved as a promenade for first class passengers. The officers' and engineers' rooms are arranged under the bridge deck; and the petty officers and crew will be berthed forward under the forecastle deck.

A new single plate rudder of increased area, and a larger and more powerful steam steering gear are fitted, and the vessel's equipment of anchors, cables and windlass renewed, and all requirements for Lloyds highest certificate complied with. A complete new installation for electric lighting is also fitted.

The designing of the alterations to the vessel was placed in the hands of Biles, Gray & Co., naval architects, and the work of lengthening and reboiling is being carried out by David &

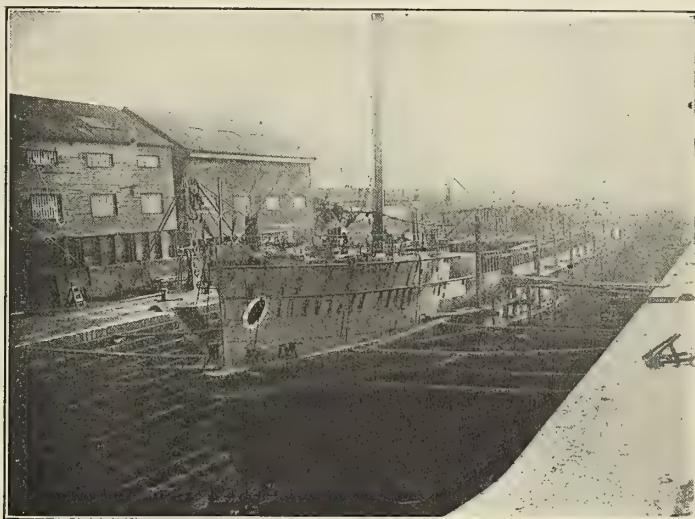


THE SEPARATION COMPLETE.

William Henderson & Co., Ltd., of Meadowside, Partick, Glasgow, under the supervision of the naval architects and the owner's representatives.

The vessel was placed in Messrs. Henderson's hands on September 29 of last year, and the work of opening up the decks and casings and removing the old boilers was immediately com-

menced. The vessel was partially cut down while afloat in the basin, and then placed in dry-dock, the bow being towards the head of the dock. The cutting of the vessel was continued simultaneously with the construction of sliding ways under the forward part. The photographs show the methods adopted, and also illustrate the final operation of drawing the vessel apart.



PLATING THE NEW HULL STRUCTURE OF THE THAMES.

The arrangements for this latter portion of the work were as follows:

A chain cable was stretched across the head of the dock and made fast at each end to a paul. A threefold wire rope was attached to the center of the chain and to an anchor buried in the ground. Two 2½-inch wire hawsers were led through the hawse pipes from triple iron purchase blocks on the forecastle head, and to the chain of a 13-horsepower winch on each side of the dock, and two 30-ton hydraulic rams were placed in the bottom of the vessel to give the initial impetus. Sights were placed along the deck to note any change in alinement.

The cutting down of the vessel and the construction of the sliding ways, etc., were completed within five days of docking, and the fore part was then drawn forward the required distance, the operation taking about nine minutes, and being accomplished without a hitch. The vessel was brought up by the checks on the ways to within a fraction of an inch of the required position, the deck sights showing no appreciable amount of deviation.

The framing of the new structure was then proceeded with, the frames, floors, beams, etc., having been already prepared from molds and templates. The plating of the bottom and sides was rapidly completed, the vessel being then undocked. The lifting in of the new boilers and the remainder of the work was done afloat.

The Steamship Irmingard.

This screw steamer, 372 feet long, 48 feet in width and with a depth of 30 feet 10 inches, has been built by the Northumberland Shipbuilding Company, Ltd., Howdon-on-Tyne, for German owners. She is fitted with a long poop, bridge and topgallant forecastle, and is arranged so that cattle, troops or emigrants may be carried. The steamer will carry about 7,300 tons dead weight. The machinery includes three boilers, 14 feet in diameter and 10 feet 9 inches long, carrying a working pressure of 180 pounds per square inch. There is one triple expansion engine with cylinders 25, 41 and 69 inches in diameter, with a common stroke of 48 inches, supplied by Richardsons, Westgarth & Company, Ltd., Sunderland. She is intended for South American trade.

A Steel Twin-Screw River Towboat.

Designed and built by the Ward Engineering Works, Charleston, W. Va., the *A. M. Scott* has a length between perpendiculars of 150 feet; length over all 151 feet; beam molded 26 feet; beam over guards 28 feet; depth molded 5 feet; sheer forward 2 feet; sheer aft 1 foot 6 inches; draft, with 70 tons of coal, 3 feet.

The hull is of best open hearth steel plate, built on a substantial framing of steel angles, Z-bars and channels. The

and a lattice truss from bulkhead No. 1 to bulkhead No. 2, hold the hull straight. No hog chains or braces are used. The deck beams are 4-inch steel channels spaced on 24-inch centers, each beam securely riveted to the shelf, and to the stringer angles on the longitudinal bulkheads and trusses.

There are four coal bunkers, with a total capacity of about 70 tons, giving a steaming radius of about 1,800 miles at 10 miles per hour. The bunkers are tight to the skin of the boat, so that by closing the bunker doors oil fuel may be used.



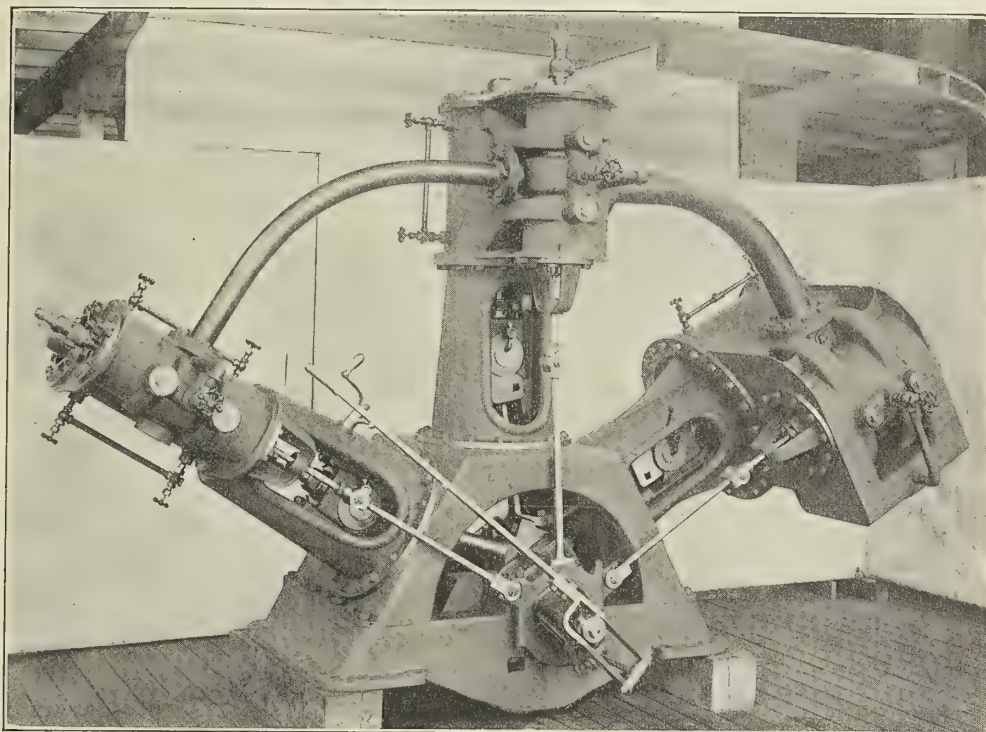
VIEW DURING CONSTRUCTION, SHOWING ENGINE FOUNDATIONS AND TUNNELS FOR PROPELLERS.

plating is just under $\frac{1}{4}$ inch in thickness; all lap seams are single riveted, the butts are triple chain riveted. The frames in the modeled part of the boat are 2 by $2\frac{1}{2}$ by $\frac{1}{4}$ -inch steel angles; in the flat 3-inch Z-bars are used; all spaced on 18-inch centers. Stringer angles are $2\frac{1}{2}$ by $2\frac{1}{2}$ by $\frac{1}{4}$ inches. A shelf or under plank sheer 18 inches wide, $\frac{1}{4}$ inch thick at the center, reduced to $\frac{5}{32}$ inch at the ends, extends around the boat underneath the deck beams, to which it is riveted. On the outer edge of the shelf is a 3 by $4\frac{1}{2}$ by $\frac{5}{16}$ -inch guard angle, which forms the backing for a 4 by 7-inch oak nosing.

The hull is divided into five watertight compartments, by four athwartship bulkheads. Two longitudinal bulkheads of $\frac{1}{4}$ -inch steel plate extending from bulkhead No. 2 to bulkhead No. 4,

The cabin or deck house is built throughout of the best California redwood, the carlins and framing of Oregon fir. The pilot house is ten by twelve feet, fitted with steering wheel, steam steering gear, and all necessary bell pulls and signals to the engine room.

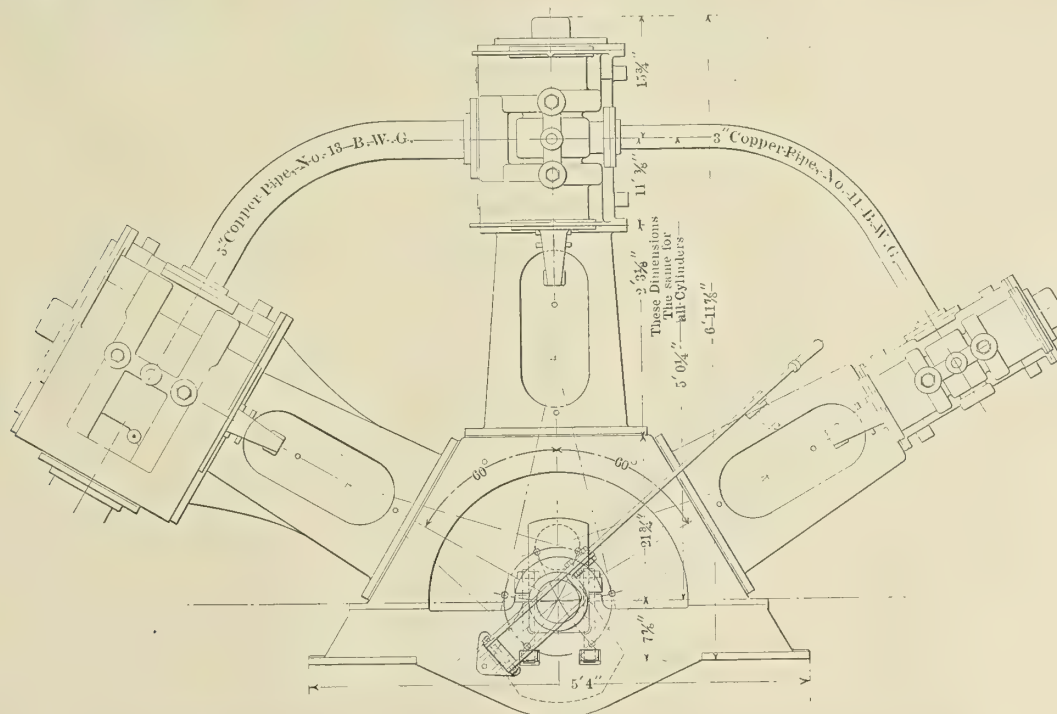
A Ward sectional watertube boiler, built for a working pressure of 275 pounds, furnishes steam under regular duty at natural draft; unusual demands are met with a blower in the stack. There are two of Ward's single crank, single eccentric, triple expansion engines. The cylinders are $8\frac{5}{16}$, $14\frac{1}{2}$, and $25\frac{3}{8}$ inches in diameter, with a common stroke of 14 inches. Two propellers, 5 feet in diameter, work in tunnels formed in the stern of the hull, as usual with this class of steamer.



ONE OF THE TWO SINGLE-CRANK TRIPLE-EXPANSION ENGINES.

There are two condensers, of the outboard sectional type, one on each side of the boat. The condensation is delivered to the hot well by a vertical air pump. The main feed is an outside-packed plunger pump, controlled by a float in the hot well. Filtered water for washing purposes is furnished by a small steam pump, discharging into a cylindrical tank in the hull, on the compressed air system, giving a very satisfactory water service. The electric plant is a 7-kilowatt direct connected General Electric outfit, complete in every respect. The steam capstan is made by the American Ship Windlass Company. All chocks and kevels are open hearth steel castings.

The boat was built as a substitute for the old style stern-wheel boats now in use on the western rivers, and has demonstrated beyond a doubt that a twin screw boat can be built with all the handling qualities and power of the stern wheel tow boats. The rudder power necessary for handling the large tows of coal is obtained in the *A. M. Scott*, by placing rudders *forward* and *aft* of the propellers, thus getting wheel water on the rudders when either backing or going ahead. Owing to the position of the after rudders, the *Scott* can steer her tow around bends that the older boat could make only by backing and flanking her tow into position, and then floating around with the current.



GENERAL ARRANGEMENT OF THE CYLINDERS ON THE SINGLE-CRANK TRIPLE-EXPANSION ENGINES.



STEAMER A. M. SCOTT, BUILT BY THE WARD ENGINEERING WORKS, CHARLESTON, WEST VIRGINIA.

Repairs to a Dynamo Engine.

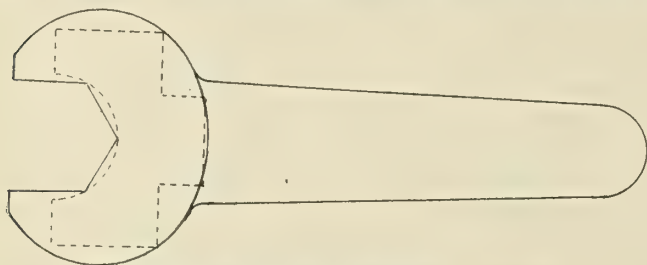
BY Q. B. NEWMAN, U. S. R. C. S.

In July, 1906, while the revenue cutter *McCulloch* was on a cruise in Alaskan waters, the dynamo engine, a 7-kilowatt General Electric, was wrecked by the breaking of a crank pin bolt. The damage consisted of a broken piston and ring, bent and upset piston rod, bent connecting rod, and other injuries of a lesser nature.

For repairs, the material available was sufficient for all purposes except to make a new piston, and the ship had a lathe

and machined to the proper size, as shown in the sketch, and holes were drilled for the crank pin bolts.

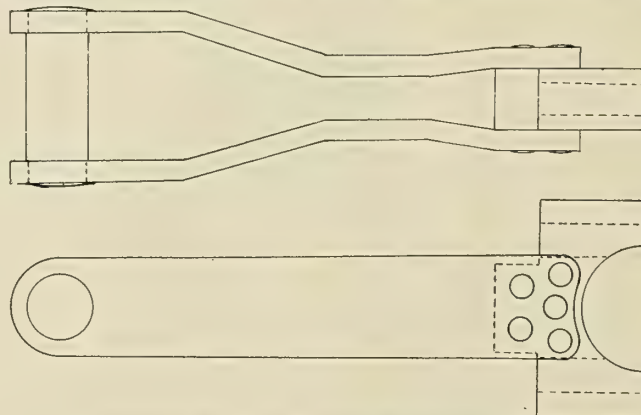
For side pieces a grate bearer-bar, 7/16 by 2½ inches, was used. These pieces were shaped and temporarily bolted to the stub end with five ½-inch bolts. A block of hard wood the length of the cross head pin was placed between the upper ends to hold the side pieces rigid while the holes for the pin were being drilled. When a new cross head pin had been turned, the bolts in the stub end were removed, and the pin was shrunk in and peened. The lower ends of the side pieces were then se-



THE WRENCH FROM WHICH THE STUB END WAS MADE.

and drill press. For a piston, a piece of cast iron was secured from the scrap heap at a mine, and drilled out and turned into shape. A spare piston rod on board was found to answer, after a bushing and a new gland had been made for the stuffing box.

When the repairs were practically finished the connecting rod disappeared, having supposedly been thrown overboard by a drunken fireman. There was nothing on board from which a connecting rod could be forged, and a search at the next two points touched at failed to produce suitable material. It was therefore decided to build a skeleton rod of material that was available. The stub end was made from a disused open ended wrench of sufficient dimensions to be cut into shape. The handle of the wrench was cut off, and the jaws were sawed, filed,



TWO VIEWS OF THE COMPLETED CONNECTING ROD.

cured to the stub with five ½-inch rivets of soft steel turned to a driving fit, annealed, and riveted cold.

The shape given to the side pieces as shown in the sketch was necessary to clear the counterweights on the crank. The completed connecting rod was found to be sufficiently rigid without the use of distance pieces, and proved to be satisfactory in every way.

THE EVOLUTION OF THE MODERN CARGO STEAMER.*

BY S. J. P. THEARLE.

The type of vessel which is employed at any part of the world for the performance of some specific work will be found generally to be of the dimensions and design which experience has shown to be most suitable for that work. The modern cargo steamer cannot be said to have yet attained to a standard condition; for, so far as can be ascertained from a consideration of the preceding stages through which it has passed, it has not yet nearly reached finality of design, nor become so fixed a type as the Thames barge, the Broads wherry, or the North Sea sailing trawler. These are doubtless survivals of the fittest among the many attempts which were made in the past to produce vessels suited for the special work they had to do. It is possible that the steamer intended for carrying general cargoes may some day become of similarly stereotyped dimensions, construction, and design, but that stage does not seem to have yet been reached. In considering, therefore, the evolution of the modern cargo steamer, we have to do with a specimen of marine architecture which is still passing through transition stages, and, although developed to a fairly high pitch of advancement, has not yet attained finality.

It will be well, perhaps, if, in the study of this interesting subject, our attention is fixed upon the ocean cargo steamer, pure and simple, without stepping aside to consider such specialised forms of the steamship as the screw collier, the coasting steamer, the passenger steamer, or the steamer for carrying petroleum in bulk. There will be quite sufficient to advantageously occupy our attention, if we restrict it to the general cargo steamer, or what is commonly known as the "ocean tramp."

The cargo steamer has from the first been screw propelled; for the variations of draft economically possible with paddle wheel propulsion are too restricted for profitable cargo carrying. It is now about sixty years since the screw propeller began to displace the paddle wheel in steam navigation, and hence our study of evolutionary development is necessarily restricted to a period of sixty years. In point of fact, however, the actual period is much shorter than that, and for all useful purposes we need no longer a retrospect than about thirty-six years. The time of the opening of the Suez canal will, it is thought, constitute a suitable epoch from which to date the genesis of the cargo steamer. She was then, it is true, something more than a mere embryo, inasmuch as she was already a ship, and an iron ship; but, except that she had an engine and boilers and additional bulkheads, she did not differ widely from the iron sailing vessel of the period. She carried masts and yards and sails, although not to the same extent as the sailer; but she had not become an entirely distinct and specialized ship.

It will be convenient to consider the subject under the twofold aspect of outline design and structural detail. For the evolutionary process has proceeded concurrently on distinct lines, and under the influence of circumstances bearing little or no relation to each other. The outline design has passed through various phases, and the structural details have at the same time undergone continuous change. The designs have varied chiefly as regards the extent and character of the deck erections; the structural details have developed mainly with the advances of the iron and steel manufacturers in the production of structural materials. The outline design has been influenced from time to time by the effects of the regulations relating to freeboard and to tonnage measurement, as well as by the opening up of new ocean trades and by modifications in the conditions under which pre-existing trade has had to be carried on. The changes in the modes of construction have been to a large extent independent of these causes, and have been marked by a continuous advance both as regards the economy of materials employed and in their

more efficient combination in the vessel. It is proposed, therefore, to consider these two aspects of the question separately, and to give attention first to the evolution of cargo steamer design.

OUTLINE DESIGN.

The earliest cargo steamers were flush decked, the machinery openings in their upper decks being protected only by low coamings and glazed skylights, and when these had been shown to be insufficient, they were succeeded by iron casings which did not extend to the sides of the vessel, nor did they partake in any degree of the character of the modern bridge house. Many of these vessels had full scantlings throughout, but in some of them the weather deck was of a comparatively light character, as also were the upper works, when compared with the scantlings at the next deck below. The vessels so designed were known as "spar-decked," and vessels with still lighter decks and upper works were described as "awning decked." It may be here remarked that the "spar-decked" and "awning-decked" vessels of to-day are more strongly constructed than were those early vessels bearing the same designation. The vessel having comparatively light upper works could not, of course, be safely loaded so deeply as vessels of full scantlings, and consequently, unless for special trades in which light cargoes were carried, they were not profitable ocean carriers when properly immersed. There were, however, no recognized tables of freeboard then in existence, and consequently the loading of vessels at that period, and for some little time afterwards, was left to the judgment of their owners.

Experience very soon showed that the machinery openings in the decks of steamers, especially those with full scantlings and therefore deeply immersed, required more substantial protection than was afforded by the ordinary casings, and consequently the first noticeable development in steamship design was the fitting of a short bridge house covering the engine and boiler openings and extending the full breadth of the vessel. To this was shortly added a topgallant forecastle, in order to keep the fore end of the vessel dry, and it was made of sufficient length to provide quarters for the seamen; also in some cases a short poop was fitted, which gave cabin accommodation for the officers. Such erections were, however, not placed upon spar or awning deck vessels; the accommodation for the crews of which was situated below the weather deck. Although at first bridge houses covered only the machinery openings, it was not long before they were increased in length beyond those limits, and poops and forecastles were also increased in size. It accordingly happened that the deck erections of some steamers built twenty-five years ago were very similar in outline to those in vessels building to-day, but they were not so substantial nor so well bulkheaded, neither did they contribute so much to the structural strength of the vessel as do those in the steamers now being built. These "three-island" steamers, as they are sometimes described, have, in fact, been built at all times during the interval, while other types that have since come into existence have ceased to be built. The "three-island" steamer of 1907 is, however, a much superior vessel to that of 1880, and the "islands" themselves are more substantial.

The type which was more immediately evolved from the flush-deck steamer of full scantlings was that with a long poop and forecastle. The long poop extended to the fore side of machinery space, and was, in fact, a poop and bridge house joined together. These deck erections, being inclosed, were measured for tonnage; but deductions from them were allowed on account of the crew and machinery spaces.

It will be evident that heavy cargo placed under a poop deck would tend very materially to trim a steamer by the stern, and hence it was disadvantageous to pay tonnage dues upon a space which could not always be utilized for cargo-carrying purposes. On the other hand, it was difficult to properly trim the flush-deck steamer when loaded, by reason of so much cargo space being taken out of the after hold in order to form the shaft

*Read before the Institution of Naval Architects, March 21, 1907.

tunnel. This was particularly the case with coal and grain cargoes, and hence there arose, especially on the northeast coast of England, a tendency to substitute a raised quarter deck for a poop, making the raised quarter deck of the height requisite for obtaining the desired trim. The erections fitted upon this type of steamer at first consisted of a raised quarter deck extending to the fore side of boiler space, and surmounted by machinery casings, and, in addition, there was a short forecastle.

An improvement upon this was found in placing a short bridge house over the machinery space, and, when this was done, we had the well-deck type, of which the "well" was the space inclosed by the bulwarks and by the bridge and forecastle bulkheads. A type of sea-going cargo steamer was thus reached, which, whatever may be its imperfections, has been found to be eminently seaworthy when properly loaded and immersed. The design, however, involved a discontinuity in the weather deck, which ultimately necessitated special structural arrangements, that added to the cost and weight of the vessel, and diminished her available cargo space. The arrangement which experience showed to be necessary, in order to maintain the longitudinal strength unimpaired at the break, involved an overlap of decks; and the special strengthenings applied at that part necessarily varied with the dimensions and proportions of the vessel. Large well-deck vessels were therefore much handicapped on that account, and, as cargo steamers increased in size, it was found disadvantageous to build them to this type when they approached a length of about 300 feet.

As already remarked, the raised quarter deck arrangement came into existence primarily for purposes of trim, and the short bridge house was associated with it for purposes of security as regards the machinery openings. From this simple type others of a more complex character were evolved. The changes commenced in the lengthening of the bridge so as to cover a portion of the forward cargo hold space, and the consequent necessity for placing hatchways in the fore part of the bridge deck. This development proceeded until at length the well was scarcely longer than was required for the No. 1 cargo hatchway. Many such vessels had been built when it at length occurred to someone that by joining the fore end of bridge with the after end of forecastle a useful reduction in the freeboard might be effected, combined with an increase in the cargo capacity of the vessel. The balance of trim was restored by increasing the fulness of the fore body of the vessel, and by carrying the machinery a little further aft; a process which commenced as soon as the fore end of bridge was extended forward of the stokehold bulkhead. The type of vessel then reached is the "part awning-deck type"; the scantlings above the level of the main deck being, however, generally in excess of those which would be required between a main deck and an awning deck. Such vessels are now rarely built, but occasionally a disposition is observed to revert to this type, which about twelve to fifteen years ago was very popular with shipowners.

Reference to this subject would be incomplete unless something was said regarding a variation which was evolved out of the part awning-deck type, which was known as a raised fore-deck steamer. In this type there is a raised quarter deck, a short bridge house covering the machinery openings, and on the fore side of the bridge house a deck corresponding to the raised quarter deck on the after side, extending to the after end of topgallant forecastle. There are, in consequence, four breaks in the continuity of the weather deck in such a vessel, viz., one at each end of the bridge, and those at the end of the poop and forecastle. Another important feature must not be overlooked. In the part awning-deck vessel there are two decks on the fore side of the raised quarter deck, viz., the part awning deck and the main deck, but only one deck abaft the bridge, viz., the raised quarter deck. In the raised fore-deck type there is no second deck in way of the raised fore-deck of the vessel. Structural

provisions were, however, made both at the after part of part awning-deck vessel and throughout the raised fore-deck vessel to compensate for the absence of a second deck when two would otherwise be fitted. Only a very few of these raised fore-deck vessels were built.

While developments in steamship design were proceeding in the directions just indicated, the "three-island" type continued to be built, with a general tendency to increase the lengths of the erections, more especially that of the bridge house. Two conflicting considerations have operated in fixing the extent of the deck erections, more especially in British-owned vessels. These are freeboard on the one hand and tonnage measurement on the other. An increase in substantially constructed and efficiently protected deck erections upon a vessel of full scantlings, permits of a reduction of freeboard and therefore of an increase in weight of cargo carried. But if these deck erections are permanently closed-in spaces, they must be measured for tonnage, and therefore dues based upon tonnage must be paid upon them.

The cattle carrying trade led primarily to some important developments in the construction and utilization of deck erections. At first a great many of the cattle were carried on the upper deck under temporary wooden protections which did not form part of the vessel, and therefore the spaces they inclosed were not measured. These temporary protections were often fitted in the wells of the three-island vessels; but, as they required frequent renewal, they became an expensive charge to the shipowner to be deducted from his freights. Ultimately some owners found it advantageous to make light permanent cattle protections of iron or steel, and to efficiently incorporate them with the structure of the vessel. The coverings of these light protections were termed shelter decks. Hence a vessel so built would have a poop, bridge, and forecastle, and two lengths of shelter decks.

From this there proceeded another change, which consisted in making the entire erection fore and aft of the same scantlings as the bridge house. But when this was done, special care had to be taken to prevent the space being of the character which must under the statute be measured for tonnage; for the shipowner did not want to pay tonnage dues on cattle spaces above an upper deck when cattle were not being carried. It consequently became necessary to leave spaces in the deck, known as "tonnage openings," in order to attain that result. At first, these tonnage openings were two or more in number, and extended right across the deck from side to side at places before and abaft the machinery space. Bulkheads were fitted at the extremities of the machinery openings, or the latter were protected by trunk casings, but 'tween-deck bulkheads were omitted elsewhere when it was desired to avoid tonnage measurement. Portable hatches were employed to cover these openings when at sea, and means were adopted for securing them in what was recognized as a temporary but efficient manner.

After a time permission was given by the tonnage authorities for the breadth of these openings to be reduced to those of ordinary cargo hatchways, and they were fitted with low coamings, and provision was made for the temporary but efficient covering of the openings with wood hatches when at sea. Recently tonnage openings have been made of still further reduced size.

By the time, however, that the shelter-deck type was evolved, it was no longer being used for cattle only, but for general cargo purposes, especially for light goods. At about the same time the experience which had been obtained with shelter-deck steamers suggested the transference of material from the main deck to the shelter deck, and this tendency has continued, until at the present time the great majority of shelter-deck steamers are built with the shelter-deck sheerstrake, side plating and deck plating of such thicknesses as to make that deck the upper member of the girder represented by the structure of the vessel. The result of this transference of material, when not associated with tonnage openings,

has been to permit of the vessel's being loaded proportionately to the structural efficiency of the upper works. When, however, tonnage openings have been made in the shelter deck, and transverse bulkheads have been placed in the 'tween decks closely adjacent to these openings, the freeboard has been approximated to that of the normal awning-deck vessel.

Our consideration of this subject brings us to an interesting stage in the evolution of that type of the modern cargo steamer known as the shelter-deck type. The shipowner has, very naturally, desired to carry as much cargo as possible on a minimum due-paying tonnage. He has also desired to load his vessel as deeply as the Freeboard Rules permit. The matter has been a simple one as regards freeboard, for the surveyors of the assigning authorities have to satisfy themselves that the statutory requirements have been complied with before recommending any particular depth of immersion. Tonnage openings must be efficiently closed before cargo can be safely carried under a shelter deck having such openings; but the manner of efficiently closing must be such that it does not fall under the description of "permanent," for in that case it would not be considered an opening at all, and the space beneath would be measured for tonnage. The whole subject is, like many others pertaining to tonnage measurement, beset with difficulties. The shipowner very properly maintains that the shelter deck is a source of safety to a vessel, and should not, therefore, be penalized by tonnage measurement when not carrying cargo. The dock and harbor boards argue from their point of view that all spaces which may at any time carry cargo should be measured for tonnage, and that dues should be paid upon them. The subject is mentioned here, not with any idea of solving the difficulties alluded to, but simply to place on record an interesting stage in the evolution of the modern cargo steamer.

Before dismissing the question it may, however, be remarked that it crops up elsewhere than in the case of shelter decks. The long bridge house, which is so important a feature in another type of cargo steamer, presents a similar problem to the tonnage measurement authorities. Long bridge houses have for the most part bulkheads at both their fore and after ends, and certainly at their fore ends. When the bulkheads are entirely closed, the bridge house has a definitely recognized value in reduction of freeboard. When there are openings in it, which are not provided with means for being efficiently closed, the bridge house has a lesser value, and when there are no bulkheads at all, it has a much smaller value.

Where there are no openings in the bulkheads, the entire space within the bridge house is measured and included for tonnage; but where there are openings in the bulkheads the space is not so measured. Means have, however, been adopted for efficiently closing the openings by what is recognized as a temporary arrangement, which gives the bridge house its full value in reduction of freeboard without at the same time being included in the tonnage measurement. In other words, the bridge erections in such cases have been deemed to fulfil all the conditions necessary for their full value to be taken into account in the reduction of freeboard. It need hardly be stated that had they not been intended to receive cargo at times, the bridge erection would have been of considerably reduced length.

This is a matter which has not yet reached a stage that may be considered final. Modifications in the modes of closing the bulkhead openings are still being made from time to time, the tendency being in the direction of satisfying the tonnage measurers that the spaces should not be measured for tonnage, and at the same time of satisfying the freeboard surveyors that they are fully efficient towards the reduction of freeboard. It should be borne in mind, when considering this question, that a long bridge house is a source of both strength and safety to a vessel, more especially when substantially constructed. Every reasonable inducement should therefore be offered to shipowners for incorporating such a desirable erection in the structure of steamers.

The growing practice of carrying cargo under deck erections has resulted in other erections being placed above them, in order to afford the accommodation to officers and to give equivalent spaces for the navigation of the vessel for those which the cargo shuts out. At first spar decks were flush, no erections being placed upon them. But today spar decks are commonly surmounted by bridge houses, poops, and forecastles, and the combined lengths of these sometimes cover upwards of 70 percent of the total length of the vessel. As already remarked, the strength of spar-deck vessels, especially at their upper works, has been so much increased beyond that of the earliest steamers of the type that the fitting of such extensive deck erections has become quite reasonable.

At first the shelter deck was formed by joining the bridge house, poop, and forecabin of a vessel of full scantlings, and so making a continuous erection which caused the vessel to appear flush decked. But to-day it is no uncommon thing to find shelter decks surmounted by bridge houses, long bridge houses surmounted by lesser ones, and even still lesser erections surmounting these in very large vessels.

When the principal scantlings were transferred from the main deck to a shelter deck, and when some of the scantlings of upper decks were transferred to the long bridge houses above them, there was at once suggested the possibility of carrying a lighter erection upon the more substantial one whenever stability conditions favored the arrangement. The appropriation of all the available space beneath the shelter deck or long bridge house for the reception of cargo made the possibility a necessity. Hence it is no unusual thing to now see a vessel with a substantially constructed long bridge house, which has upon it a less substantial and shorter bridge, providing the officers' accommodation, and this again surmounted by a navigating bridge, chart house, and steam steering wheel house. The structural arrangement necessary to insure the safety of the whole is, of course, a detail which has received due attention.

A study of the changes which have taken place in the external arrangements of the cargo steamer would be incomplete without a reference to the subject of masts and sails. The cargo steamer commenced her history as a masted and rigged vessel, carrying both square and fore-and-aft canvas, and capable of sailing at a slow speed should her machinery break down. As time went on the extent of the masting and of the sail power gradually diminished until the opening of the Manchester canal in the year 1894, when it became necessary for all steamers using that inland waterway to have masts much shortened from the then prevailing practice, and made telescopic, in order to pass under the bridges crossing the canal. Even for some time previous to that date very little more than fore-and-aft sail (that is to say, jibs and stay sails) was carried on most cargo steamers. At the present day it is not unusual for steamers to be provided with no sails at all, or with but a very small amount. The masts now, for the most part, serve the purpose of derrick standards in port, and for light and signal hoisting at sea. Indeed, in some cases the derrick standards are not even placed at the middle line of the deck, but are grouped in two parallel rows.

And here allusion, however brief, should be made to the great advances in regard to the rapid loading and discharging of cargoes, which have of late attended the development of the cargo steamer. These have not only shortened the time of the vessel's stay in port, and thereby increased her freight-earning powers, but they have also materially reduced the cost of handling the goods and, by their efficiency, have added to the safety of the dock laborer's employment.

SIZE AND PROPORTIONS.

Before considering the internal structural changes which were simultaneously going on in the cargo steamer, a few words are necessary in regard to the increases in size and modifications in proportions and form which took place throughout the period

under review. It is a matter of common observation that the cargo steamer is larger than she used to be, but the growth of the cargo steamer has not been relatively so great as that of the passenger steamer. The average gross tonnage in the year 1870 of the cargo steamers then afloat was about 870 tons, and the cargo steamers built during that year had an average gross tonnage of 1,050 tons, cargo steamers of 1,100 to 1,400 tons being very common. In the year 1880 the average tonnage of cargo steamers then afloat was about 1,330, while the average size built in that year was about 1,580 tons, steamers of 1,200 to 2,000 tons being common. The average tonnage of the cargo steamers afloat in 1890 was about 1,500 tons, and that of the steamers built during that year was about 2,150 tons, a great many of the steamers being between 2,000 and 3,000 tons. In the year 1900 the average tonnage of steamers afloat was about 1,900 tons, and the gross tonnage of the steamers built during that year averaged about 3,000 tons, very many of the steamers being between 3,000 and 4,000 tons.

By the year 1905 the average tonnage afloat of cargo steamers had increased to about 2,250 tons, and the average tonnage of cargo steamers built that year was about 3,300 tons. At the present time the great bulk of cargo steamers range between 3,000 and 4,500 tons. There is not just now a marked tendency to build cargo steamers of a larger size, but rather to build a greater proportion of the total number in sizes between 4,000 and 4,500 tons, these being apparently the tonnages found most suitable for the general ocean carrying trade. Much larger cargo steamers are, of course, built, but they are for the most part associated with certain well-known passenger lines, chiefly in the Atlantic trade. The ordinary cargo steamer of to-day ranges in length from about 300 to 380 feet.

For vessels which have to go seeking, which is the case with the average cargo steamer, it is most important that their draft of water should not exclude them from any port where cargoes may be obtained. It is this question, then, of draft of water which limits the dimensions of such vessels; for draft fixes depth, and within a small range depth limits length. The ratio of breadth to depth adopted in cargo steamers does, however, show some variation. About forty years ago, and for many years afterwards, cargo steamers were frequently relatively narrower than they are to-day. It was thought at that time that reducing the breadth tended to diminish the resistance to a vessel when steaming, and in consequence many steamers were built of a full scantling type, known as three-decked, in which the relation of depth to breadth was such as to result in a serious deficiency of stability when loaded with a homogeneous cargo.

The late Mr. Martell, in a paper read by him before this institution in 1892, stated that the average ratio of depth of hold to the breadth of steamers built in 1879 was about 0.69, but by 1890 the proportion had fallen to 0.62; so that while the average breadth of a vessel of 24 feet depth of hold was 34.8 feet in 1879, it had increased to 38.9 feet in 1890. It need hardly be said that no increase of resistance to speed attended such an increase of breadth, when suitable lines were adopted for the vessel. The tendency to increase the breadths of cargo steamers in relation to their registered depths has since continued. In the year 1900 the average ratio of depth to breadth had diminished to 0.50, and in 1906 it was 0.48, only. It should be explained that these proportions occur in vessels of full scantlings. Shelter-deck vessels have a greater depth to shelter deck in proportion to their breadth, and consequently such vessels would show a higher ratio than those given.

The cargo steamer of to-day is not fine lined, nor has she been for many years. Her owner has to judiciously associate conflicting forces in the interests of profit earning. He wants to carry as much cargo as possible upon a certain draft of water, and to deliver that cargo as speedily as possible at its destination; but he does not want the ship which does this to stand him in a larger first cost than can be avoided, nor to cost more than can be helped in coal, stores, and the other expenses attendant upon

navigation. He has, therefore, to strike a judicious mean, and the result is the cargo steamer as we see her. It is in the constant effort to effect economies of first cost and actual working, and to increase results in freight earning, that the struggle has consisted which results in this survival of that which up to now has proved to be the fittest. Future evolutionary changes will be the further result of this economical conflict. The modern cargo steamer has practically a flat bottom, with very little rise of floor, and with a fulness of form resulting in a displacement coefficient averaging 0.81. To show how the tendency to fulness of form has gone on of late years it may be mentioned that the average displacement coefficient in 1880 was 0.74, in 1890 it was 0.77, and in 1900 it was 0.80. With the engine power usually supplied, this vessel has a seagoing speed of from 8 to 10 knots when fully loaded, while her speed in a light condition will vary much in accordance with the manner and extent of her ballasting.

And this brings us to a subject which has profoundly influenced the genesis of the cargo steamer. Up to about twenty years ago steamers employed in the ocean carrying trade did not often make voyages in ballast. Wherever they went they for the most part took a cargo of some kind or another. But since the United States has set up a restrictive tariff which practically excludes British manufactured goods, the great bulk of our trade with that country has been of a one-sided character. Our ships have had to make the westward passage of the Atlantic empty in order to get a cargo for the eastward passage. This fact has had a very marked effect upon the construction of the modern cargo steamer, which must be designed so as to be suitable for any work which she may be reasonably required to perform. Hence, in order that she may be suitably ballasted for going westward across the Atlantic in winter without a cargo, it has been found necessary to fit tank arrangements for carrying water ballast, which otherwise would not have been necessary. But, what is of greater importance, experience has shown that the straining conditions when ballasted are of such a marked distinctive character when contrasted with those encountered in a loaded condition, that special structural provision for them must also be afforded. These will presently be considered in detail, and reference to the matter is now made only because of its bearing upon the question of speed maintenance under both loaded and ballasted conditions.

We have now followed, in as consecutive a manner as the story will permit, the evolutionary process which has gone on during the past thirty-five or forty years in the production of the modern ocean cargo steamer, in so far as regards her external form and outline. We have seen how the various arrangements of deck erection originated, and how forms were evolved out of preceding ones. We have in this manner arrived at the normal types which now prevail. It would be foreign to the purpose of this paper, and tend too much to the introduction of controversial matter, to consider the evolutionary position of such forms of the modern cargo steamer as the "turret-deck" or the "trunk-deck" types. These, it is suggested, may well be made the subjects of papers from the pens of those who have been instrumental in bringing them into existence, and to whose ingenuity they are due.

(To be concluded)

The Irish International Exhibition.

From May to October of 1907 will be held in Dublin an exhibition covering nineteen sections of industry, and to which foreign countries have been invited to send exhibits. Engineering and shipbuilding will be taken care of, and among the concerns to be represented might be mentioned Messrs. Harland & Wolff, of Belfast, the White Star Steamship Line, the Cunard Steamship Company, the Royal Pacific Steam Packet Company, and the Babcock & Wilcox Company. The main building will have an octagonal court, 215 feet in diameter, surrounded by a corridor into which open four radial wings, each 164 feet long and 80 feet wide.

The Engineering Societies Building.

During the past twenty years the project has been frequently discussed and agitated of bringing together in one building, with proper facilities for offices, library, auditorium, meeting rooms, etc., the various engineering societies that make their headquarters in New York City. In February, 1903, Mr. Andrew Carnegie gave \$1,000,000 to erect a suitable union building. One year later, when the plans and estimates showed that a larger sum would probably be required to carry out the work on an adequate basis, Mr. Carnegie in a further letter, addressed to the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, and the Engineers' Club, increased his sum to \$1,500,000 in their joint behalf.

The only limitation on the gift was that it should be devoted to the erection of a building, the bodies interested buying the land. At the outset it was proposed to put up one building on Fortieth street, but owing to the difficulties involved in the purchase of as much land as would be necessary and in combining under the one roof all the social and technical functions exercised by these organizations, it was decided to erect two separate buildings, one for the Club on Fortieth street, and one for the three professional societies on Thirty-ninth street, the two buildings to be placed in such relationship and contiguity that access from one to the other would be easy and the underlying common purpose thus be subserved to the full extent. The division of the buildings was accomplished by allotting \$1,050,000 to the Engineering Societies building, and \$450,000 to the Club building.

The site acquired for the Engineering Building is on West Thirty-ninth street, north side, between Fifth and Sixth avenues. The contract for the construction of the building was executed with Wells Brothers Company on July 17, 1905. The cornerstone of the building was laid in the eastern wall by Mrs. Carnegie on May 8, 1906. Offices were ready for occupancy on December 15, 1906; some were in use before the end of the year, and the entire building, though not quite finished, was ready for use January 1, 1907.

The frontage of the building is 115 feet, and the depth is 90 feet. The property itself is 125 feet front by 110 feet depth. The building laws of the City of New York require that only 85 percent of the lot area shall be occupied by the structure on it. The



THE ENGINEERING BUILDING, NEW YORK.



A VIEW IN THE SPACIOUS LIBRARY ON THE THIRTEENTH FLOOR OF THE NEW BUILDING.

figure for this building is 75.3 percent. Advantage has been taken of this limitation to give the building a monumental appearance. It is designed in the French style, and rises 13½ stories above the sidewalk, to a height of 218 feet 6½ inches. The exterior is built of limestone up to the auditorium floor, and of gray mottled brick and terra cotta above; the whole having a cheerful cream tint on all four sides. The treatment is restrained and dignified, but without severity. As the lower portion is devoted to auditoriums, the middle section to offices, and the upper part to the library, an effort has been made to accentuate these three separate parts of the building, with happy result, as shown by the engraving. The total weight of steel employed in building construction is 2,650 tons. All the steel work has been covered with from 2 to 4 inches of semi-porous terra cotta, and the columns are grouted with concrete. The floors are built with terra cotta 6-inch segmental arch construction, overlaid with 5 inches of cinder concrete. All exterior walls are furred with a 2-inch terra cotta block, to prevent any possibility of moisture being driven through the walls.

class are the *Inflexible*, launched at the Clydebank works of John Brown & Co., Limited, and the *Invincible*, at the Elswick yard of Sir W. G. Armstrong, Whitworth & Company., Limited, at Newcastle-on-Tyne. All three ships are identical in design, their auxiliary machinery is interchangeable, and the turbines in all the ships are alike in their general dimensions, so that a turbine may be transferred from one ship to another. The keel of the *Indomitable* was laid on March 1, 1906; the *Inflexible* on February 5, and the *Invincible* on April 2, 1906. All three vessels will be completed for service fifteen months hence, nearly within the contract time of two years and three months.

The following are the officially withheld dimensions of the *Indomitable*:

Length	530 feet.
Breadth	78 feet 6 inches.
Draft	26 feet.
Weight of hull	9,660 tons.
Displacement	17,250 tons.
Block coefficient	0.558



BOW VIEW OF THE ENGLISH BATTLE-CRUISER INDOMITABLE, JUST BEFORE LAUNCHING.

The Ship of Mystery.

BY BENJAMIN TAYLOR.

The new type armored cruiser *Indomitable*, in reality a very swift battleship, built by the Fairfield Shipbuilding & Engineering Company, Glasgow, for the British navy, has been called the "Ship of Mystery," because neither the builders nor the Admiralty would supply to the newspapers any details of her structure and armament. No warship ever built has excited so much curiosity, because of none has so little been known, while so much was expected. We are able to supply some particulars of this remarkable vessel, which was successfully launched on March 10, on the Clyde. The launch was perfect in all the arrangements and in the working out of the mechanical details, and the result was a triumph of shipbuilding skill. The vessel moved slowly at first, and her progress was so uniform that there was no moment of anxiety. From the time she began to move until she was all afloat was 1 minute 22 seconds.

The *Indomitable* is one of three ships of a new class, to have great fighting power and high speed. The other two vessels of this

Horsepower	41,000
Speed	25 knots.
Admiralty coefficient	254
Coal capacity at load draft.....	1,000 tons.
Cost	£1,744,000

The *Indomitable* will have complete broadside armor from bow to stern, the maximum thickness being 7 inches, tapering to 4 inches at each end. This armor extends from under the water line to near the upper deck. The guns are within 7-inch barbettes, and have large armor hoods. There will be numbers of machine guns for defense against torpedo attack.

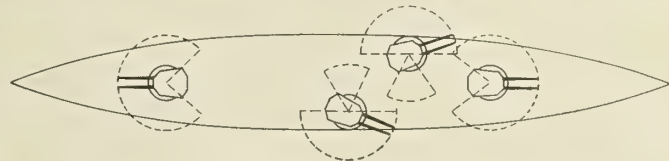
The propelling machinery is of the Parsons steam turbine type. Steam is supplied from Yarrow watertube boilers. There are four shafts, as in the *Dreadnought*. On each of the two inner shafts is a cruising turbine, a low-pressure ahead and a low-pressure astern turbine, while on each of the outer shafts is a high-pressure ahead and a high-pressure astern turbine. For low powers the steam passes through three turbines before entering the condenser. The blades of the turbines vary in length

from less than 1 inch up to 16 inches. There is a longitudinal bulkhead dividing the port and starboard engine rooms, in each of which are five turbines and a condenser.

The design of the *Indomitable* marks a great departure from preceding ships. The line of demarcation in the work of the battleship and cruiser has been that the one was designed solely for taking part in the line of battle, and the other was intended as a commerce protector or scout. The great advances made in recent years in connection with munitions of war now necessitate modifications in tactics, and even in strategy. The effect is now to bring about an assimilation in the designs and possible service of each. Wireless telegraphy has greatly affected the work of the cruiser, and has simplified the duty of protecting commerce. British cruisers will hereafter follow tactics associated with the maintenance of the command of the sea, and will work in squadrons, but they will also undertake reconnaissance in force. The combined risks are great, and demand high gun power along with speed. Therefore the *Indomitable* and her consorts will be better equipped than any of their predecessors, being equal to the best battleships, and superior to nearly all ships, in gun power, and also in protection.

In armament the advance is enormous. The *Australia* had 9.2-inch guns, as have the *Cochrane* and *Minotaur*, but the earlier

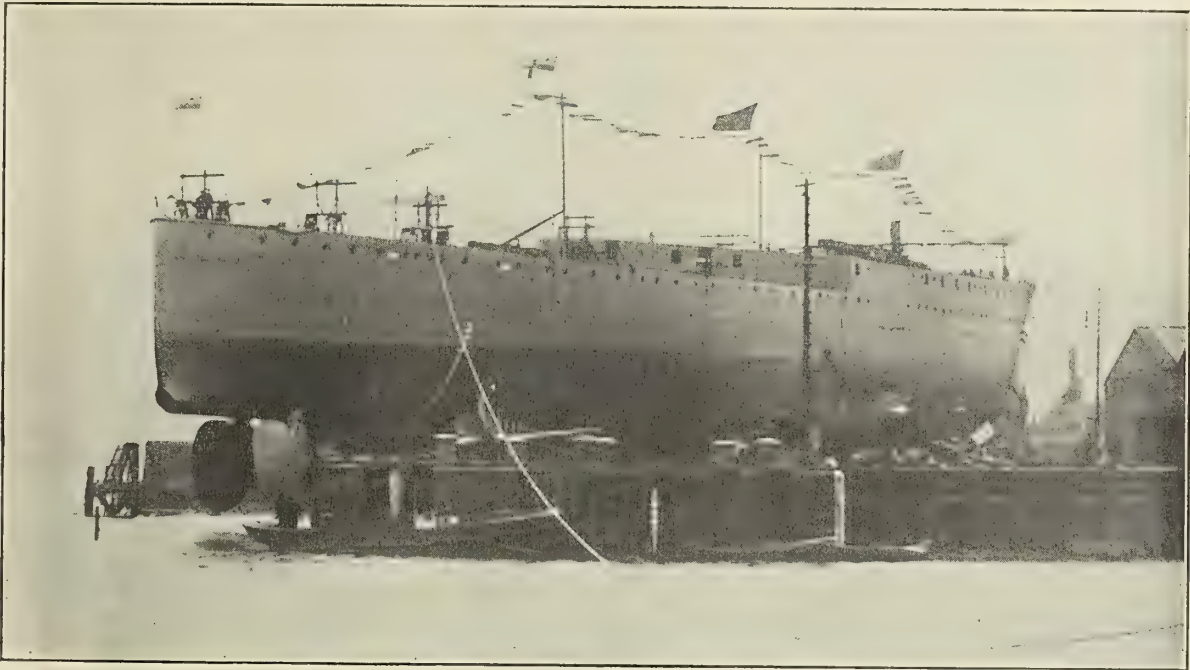
The bow guns are on the center line forward, and on the same high level there is amidships on each broadside a pair of 12-inch guns in barbettes, not in the same athwartship line. The barbette on the port side is sufficiently farther forward than that on the starboard side to enable all four amidship guns to fire on either



THE BATTERY ARRANGEMENT OF THE INDOMITABLE CLASS.

side. The broadside fire of the new ship is thus immensely superior to that of any other, being 381,576 foot tons. There is a corresponding gain in bow and stern fire, as the ship will be able to fire six 12-inch guns ahead and six astern.

These qualities have been earned at considerable cost. The length of the *Indomitable* is 30 feet greater than that of any preceding British cruiser, and the displacement is 2,650 tons more than any predecessor. The leading particulars of notable British cruisers are given below:



THE INDOMITABLE JUST BEFORE LAUNCHING, SHOWING THE TWO RUDDERS, AND TWO OF THE FOUR PROPELLERS.

weapons of this caliber had a muzzle energy of only 8,622 foot tons, against 20,685 foot tons of the present gun of the same bore. The 6-inch gun has ceased to be regarded as satisfactory for primary armament. It was found that the disturbance of the air around a ship in consequence of rapidity of fire caused refraction of light to such an extent as to prevent accurate aim, so that there was set a limit to the rapidity of hits in a given time. When the unity of caliber was fixed, and it was realised that the refraction put a limit to rapidity of fire, it was resolved to adopt all 12-inch guns in the latest ships. The armament of recent cruisers has thus varied:

	Guns.				Foot Tons
	12-in.	9.2-in.	7.5-in.	6-in. one round.	
<i>Good Hope</i>	2	..	16	..	82,700
<i>Donegal</i>	..	..	14	..	46,984
<i>Cochrane</i>	6	4	..	..	161,470
<i>Minotaur</i>	4	10	..	..	176,140
<i>Indomitable</i>	8	..	..	..	381,576

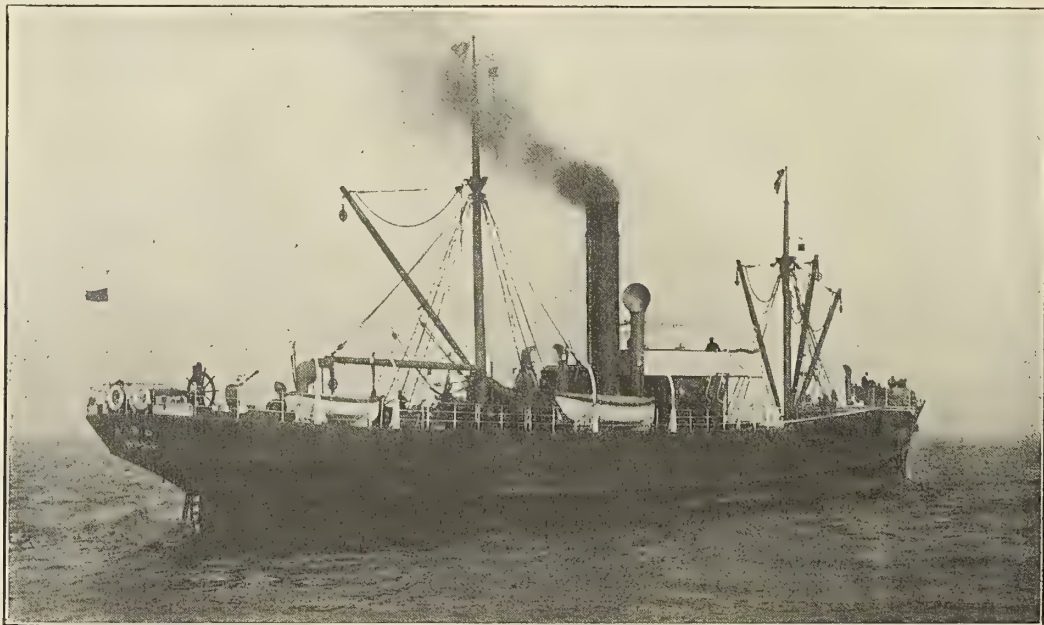
All the guns of the *Indomitable* can fire on either broadside.

Name.	Date.	Length.		Displacement.	I. H. P.	Designed		Cost.
		Feet.	Tons.			Speed.	Knots.	
<i>Australia</i>	1889	300	5,600	8,500	18.5	258,000	£	
<i>Edgar</i>	1890	360	7,350	12,000	20.5	410,980		
<i>Diadem</i>	1896	435	11,000	16,500	20.5	554,800		
<i>Terrible</i>	1895	500	14,200	25,000	22.5	708,600		
<i>Cressy</i>	1899	440	12,000	21,000	20.75	749,000		
<i>Good Hope</i>	1901	500	14,100	30,000	23.5	990,000		
<i>Donegal</i>	1902	440	9,800	22,000	23.0	715,900		
<i>Cochrane</i>	1905	480	13,550	23,500	23.0	1,129,500		
<i>Minotaur</i>	1906	490	14,600	27,000	23.0	1,410,000		
<i>Indomitable</i>	1907	530	17,250	41,000	25.0	1,744,000		

In 1889 the armor belt was discontinued, as it was considered less efficient than heavy protective deck plating. From 1890 to 1899 the cruisers were all built without side armor, but with deck plates, which attained a maximum thickness in the 6-inch curved deck of the *Terrible*. The process of hardening armor by cementation and chilling gave material with higher resistance to

penetration by projectiles, and in the *Cressy* side armor was again adopted, but at the same time metals of higher tensile strength were available. The proportion of the displacement absorbed by the hull has thus decreased. In the *Diadem* it was 63.5 percent; in the *Donegal* it was 60 percent; in the *Cochrane* it was reduced to 59 percent; in the *Minotaur* 56.3 percent; and in the *Indomitable* 56 percent.

The earlier ships had proportions of 6 of length to 1 of beam, the later ships have about 7 of length to 1 of beam, though the draft is now limited to 26 feet. Greater length allows of a finer form, and improves the speed for a given power, therefore, a higher propulsive efficiency is realised in the later ships. The *Donegal*, of 440 feet in length, required 2.25 horsepower per ton of displacement to get 23 knots, while the *Cochrane* (480 feet) got the same speed for 1.73 horsepower per ton. The *Indomitable* is to get 25 knots for 2.38 horsepower per ton of displacement.



THE STEAMSHIP FIDO, BUILT BY EARLE'S SHIPBUILDING AND ENGINEERING COMPANY, LIMITED.

The Steamship Fido.

On the 16th day of March, 1906, the steamship *Fido* was launched from the yard of Earle's Shipbuilding and Engineering Company, Limited, Hull. This ship has been built to the order of Thomas Wilson Sons & Company, Limited, and is intended for their Newcastle trade. The principal dimensions are: Length, 178 feet; breadth (molded), 29 feet 6 inches; depth (molded), 14 feet 10 inches.

The vessel is constructed of steel to British Corporation highest class, and to the Board of Trade requirements. She has a long poop and topgallant forecastle, two pole masts of steel, fitted with strong derricks, and all necessary cargo gear. There are three steam winches of Lynn & Company's special make, steam windlass by Clark, Chapman & Company; steam steering gear by Amos & Smith, and hand steering gear by Hastie & Company.

A steel deck-house has been provided on the fore end of poop for chart-room and steering gear. The captain, officers and engineers are berthed in the poop 'tween decks, each having commodious rooms. The forecastle has been fitted up to accommodate seamen and firemen.

The propelling machinery consists of a set of triple expansion engines, having cylinders 14½, 24 and 40 inches in diameter, with a stroke of 27 inches, steam being supplied by a large single-ended cylindrical boiler, working at a steam pressure of 180 pounds per square inch.

JAMES FISHER.

POINTS OF INTEREST IN CONNECTION WITH THE
DESIGN, BUILDING, AND LAUNCHING OF THE
LUSITANIA.*
BY W. J. LUKE.

When the decision to build the two vessels now being constructed for the Cunard Steamship Company was made, the number of large fast transatlantic liners was seventeen, and the principal particulars of the five fastest are set out in the table.

The conditions which it was demanded should be fulfilled were somewhat in advance of what was eventually found to be reasonably practicable; in the end, after the Cunard Company had instituted a committee of inquiry into the question of turbine propulsion, and after prolonged and valuable assistance from the Admiralty officials through the testing of models in the Haslar experimental tank, it was decided that the dimensions and principal particulars were to be as follows:

Length over all 787 feet.
Length between perpendiculars 760 feet.
Breadth molded 87 feet 6 inches.
Depth molded to shelter deck amidships.... 60 feet 4½ inches.
Displacement at 32 feet 6 inches draft..... 36,440 tons.

	Campania	Kaiser Wilhelm der Grosse	Deutschland	Kronprinz Wilhelm	Kaiser Wilhelm der Zweite
	ft. in.	ft. in.	ft.	ft.	ft. in.
Length over all.....	622 0	648 6	684	663	706 6
Length B. P.....	600 0	625	663	—	678 0
Breadth.....	65 3	66	67	66	72 0
Molded depth.....	41 6	43	44	43	44 2
Ordinary draft.....	25 0	28	29	29	29 6
Displacement, tons	18,000	20,880	23,620	21,300	26,500
Reputed speed, knots	22	22.8	23.5	23.5	23.5
I. H. P.....	30,000	32,000	36,000	36,000	39,000
Grate surface, sq. ft.....	2,630	2,618	2,188	2,702	3,121
Heating surface, sq. ft.....	82,000	84,285	85,468	93,865	107,643
Type of draft.....	Open Stokehold	Open Stokehold	Howden's Forced	Open Stokehold	Open Stokehold

*Read before the Institution of Naval Architects, March 21, 1907.

The contract for the *Lusitania* was placed with John Brown & Co., Ltd., of Sheffield and Clydebank, who are builders of both hull and machinery, and the contract for the sister vessel, the *Mauretania*, was placed with Swan, Hunter & Wigham Richardson, Ltd., of Wallsend-on-Tyne, with machinery in this case by the Wallsend Slipway Company. The subsequent particulars have exclusive reference to the former vessel, though it will of course be at once apparent that for sister ships building for the same owners, at the same time, very many of the particulars and details are common to the two cases.

The building berths at Clydebank are situated on the northern side of the Clyde, opposite to the mouth of the small tributary the Cart. The expanse of water into which launching takes place is, however, not unrestricted, and for this reason, as well as taking the present slope of the berth into consideration, it was decided to lay the keel at a slope of 7-16 inch per foot, and to arrange for a launch at a mean slope of 51-100 inch per foot. These figures enabled the vessel to be placed at a satisfactory height from the ground, while excessive height of blocks at any place was avoided; and with the probability of a launch in moderately warm weather, it gave enough slope to the ways to promise a successful launch without undue chance of exposing the vessel to risk in the restricted available waterway. Careful attention was given to piling the ground at the places where heavy pressure would necessarily come upon it in the launching operation. On other parts of the berth no special precautions were required, as the ground was well consolidated, and the size of ship in relation to the estimated weight of material worked in before launching made it sufficiently evident that the vessel would not be (in this sense) heavy. For this reason, too, the keel blocks were spaced and constructed in normal fashion.

It was decided that, on the basis of mild steel construction, the materials of the hull should not be subjected to a stress exceeding 10 tons per square inch. The calculations in this connection gave consideration to the possibility of the vessel's meeting with waves of her own length, and whose height from trough to crest would be one-twentieth of the wave length. In the calculation for inertia of section such parts were included (or omitted) as had previously been customary. In view of the fact that no attempt was made to make any estimate of the stresses due to pitching and 'scending or of heaving, the stress of 10 tons previously mentioned must be considered purely comparative in amount.

The preliminaries having been thus adjusted, calculations were proceeded with, the results making it apparent that the maximum bending moment (of slightly over one million foot tons) occurred in the condition when nearing port with bunkers almost empty. The stress is one of hogging, the corresponding sagging stress being only about half this amount. It may be remarked that the corresponding bending moments in a load condition, assumed at a displacement of about 20 percent in excess of the arrival displacement, are slightly less for hogging, and for sagging are not very different from the case previously considered.

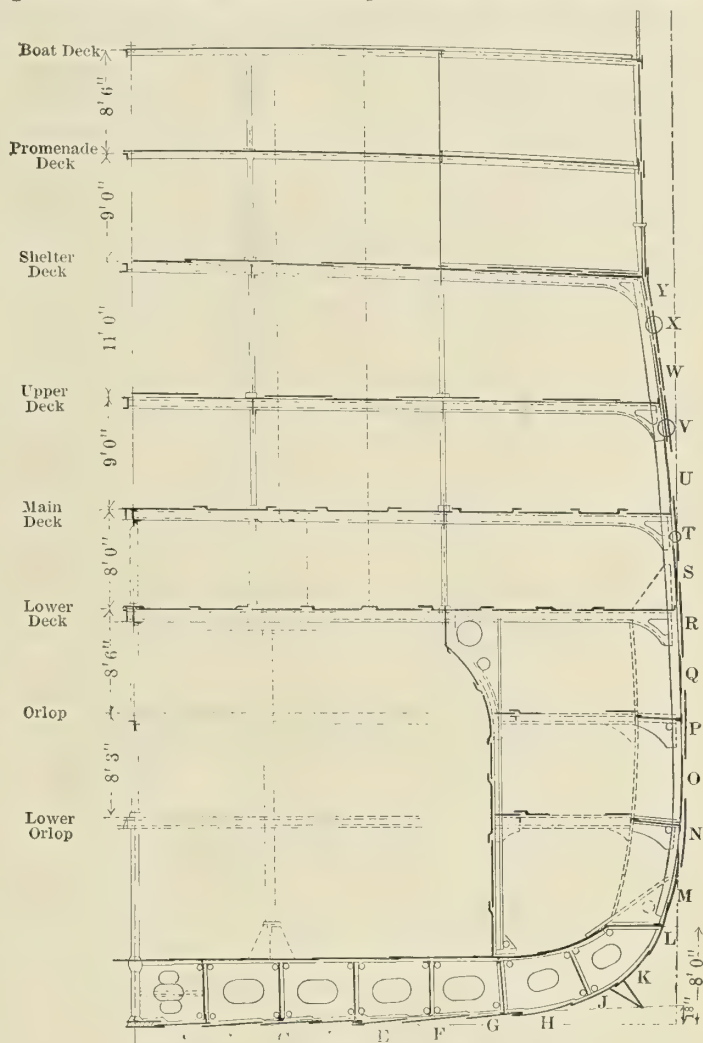
SCANTLINGS.

The structural details, in so far as they are usually determined on the midship section, were, in consequence, got out for mild steel on the basis of these calculations. In view of the fact that the severest stresses were such as put the upper works in tension, it was determined to adopt high tensile steel of reduced scantling in these parts, provided such material could be produced of satisfactory quality. The investigation into this matter occupied some time, but fortunately, owing to the position in which it was intended to use the new material, no hindrance to the progress of work resulted from this investigation. In the end, it was demonstrated that a satisfactory material could be produced, whose average ultimate tensile strength was at least 20 percent greater than the average for the usual quality of mild steel, and in consequence a reduction in certain scantlings of 10 percent from the scantlings fixed for mild steel was adopted. This reduction not

only caused considerable saving in weight, but made for better riveting, owing to the thinner plates and smaller rivets used.

It also has the effect of lowering the neutral axis of the transverse section, and increasing the stress on the material beyond the accepted limit for mild steel, but this increase of stress comes entirely on high tensile steel, and is very moderate in amount. Full details of the calculation for the moment of inertia of the section are given subsequently; the midship section is illustrated, and the list of scantlings is appended.

It will be noted that five continuous longitudinal girders are adopted, viz., the center keelson, the margin plates, and the fifth girder on each side. The watertight division of the ballast tanks



MIDSHIP SECTION OF CUNARD STEAMSHIP LUSITANIA.

is made by the center keelson and the margin plates only (in association, of course, with watertight floor plates), no attempt being made to make watertight the intermediate continuous longitudinal.

The floor plates are spaced at 32 inches centers for a length of about 300 feet amidships; at the ends the spacing is 26 inches forward and 25 inches aft, the closing in being gradually performed. They are 60 inches deep amidships, and have a maximum width at the margin plate of 48 inches, this latter point being to some extent governed by the joint effect of the convenient depth of bottom worked to in association with the adoption of a level margin at the height chosen. In association with the continuous longitudinal keelsons previously noted, it will thus be seen that the floor plates are in one length from the middle line to the fifth keelson, and from thence to the margin they are also in one piece, this arrangement leading to convenient floor plates below, and to the avoidance of inconvenience at the turn of the bilge. They are generally 10-20 inch thick, except under the boiler stools,

in which case (following a common precedent) they have been made 2-20 inch thicker. It may incidentally be mentioned that, owing to the great depth and the comparative closeness of the frames, the lightening holes in the longitudinals are arranged with their larger dimension placed vertically, and one has therefore the rather curious experience of being able to *walk* with comfort through each frame space of the ballast tanks. The frames and reverse bars up to the margin plate are joggled to avoid the necessity for slip irons.

The flat plate keel is in three thicknesses, as shown. It will be seen from this sketch that the connections of the parts forming the center girder are arranged in the usual manner, the only points which are unusual being the connection of the garboard plates to the flat keel plates, and the fact that the longitudinal connecting angles have no butt straps. All the plates in this combination are at least 32 feet long; they have well shifted butts, and the whole of the riveting is performed by hydraulic power. Having regard to the great necessity of securing fair holes, only the inner thickness of keel was punched, and the plates being assembled correctly, the holes through the remaining thicknesses were drilled in place. The plates were then separated, and drillings, etc., removed from the faying surfaces; the edges of the holes were slightly reamed, and the whole reassembled for riveting. The connecting bars for the center keelson were riveted first and before the garboards were put in place; experience in the *Caronia* and *Carmania* (where a somewhat similar keel construction has been adopted) showed that the closing power of the hydraulic riveter was such that it was necessary to get the garboards in place before any other riveting on the flat keel was proceeded with, and this course had to be followed. The garboards were therefore got into place at a very early stage of the work, and before any transverse frames were erected; the riveting machines were naturally of very large gap, and the necessity for keeping them within practical limits has led to the adoption of a width of plates in this connection, which (but for this explanation) might be considered rather low. It will be noted in passing that this combination of keel plates avoids the necessity of butt straps, which fact was considered of some importance—at least as regards the straps on the outside.

The next point which deserves notice is the shell plating on the lower part of the bottom. This plating is worked clinker fashion, the frame bars being joggled to avoid the use of tapered slips, and the plates are lapped in the way shown for convenience in riveting. A large portion of the shell riveting, in fact nearly all of it to the turn of the bilge, has been done by hydraulic power, and as the closeness of the frames and floors made it quite impracticable to use machines of large gap, no course was open but to lap the plates as shown. Each strake could in this way be riveted right up to the edge seam connecting to the next strake to be brought on. In this lower portion of the bottom, the edge seams are double riveted, and the butts have double straps, the outer being double, and the inner treble riveted, with openly spaced rivets in the third row. The edges of the outer straps are slightly chamfered. The whole of the riveting in the double bottom for connecting the transverse and fore-and-aft framing is performed by hydraulic power. The inner bottom plating calls for no special remark; the riveting is necessarily performed by hand.

From a little above the turn of the bilge the plate edges are sheered in lines approximating to the sheer of the ship, and the strakes below are worked as stealers into the edge of the lowest of the parallel strakes, thus avoiding an excessive number of narrow strakes at the bow and stern. A little care was necessary in carrying out this disposition, to arrange that each bilge keel could be worked entirely on one strake, and in this way long and awkward crossing of lines of rivets in plate edges was avoided.

In the wake of the engine rooms the framing is considerably deeper than in the remaining portion of the bottom, and additional fore-and-aft girders are introduced in order to provide beds of suitable height and stiffness for the propelling machinery. A

typical section (in outline) is shown. It is obvious that the arrangement is applicable only to this case, and would require to be varied according to the number, width, and height of the shafts, the size of the machinery and the method of supporting it.

The frames above the margin are formed of channels 10 by 20-40 by 4 by 4 by 23-40 inches for 3-5 length amidships to 9 by 20-40 by 4 by 4 by 23-40 inches, secured by heavy brackets to the margin plate and fortified by web frames averaging four frame spaces apart. These channel frames are continuous from the margin plate to the shelter deck.

The shell plating above the turn of the bilge is worked with lapped edges and with lapped butts where in one thickness. The plates are generally about 33 feet long, that is, twelve frame spaces, plus the lap of the butt; the edges are treble riveted and the butts quadruple riveted. A considerable portion of this plating is of high tensile steel, as is shown, the lightly hatched parts being of one thickness only, and of the same scantling as would have been adopted for mild steel, the more heavily hatched portion being in two thicknesses and of reduced scantling, in consideration of the strength of the material. Throughout the region of doubled thickness, hydraulic riveting was adopted. The edges are treble riveted, and the butts of the doubled portion are strapped outside and inside at butts of the outside plates, the outer straps taking three rows of rivets, and the inner straps four rows; the thicknesses of the straps are reduced on account of the doubling. The butts of the inside plates are strapped on the inside and quadruple riveted.

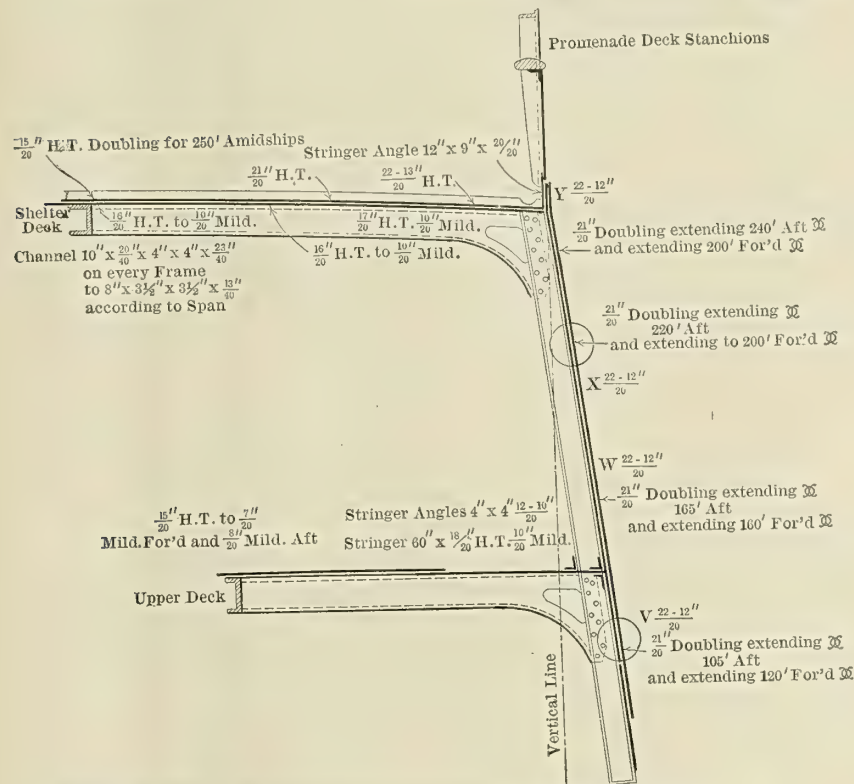
All the holes in the high tensile steel were drilled, and more than usual care was adopted to clean off all drillings, etc., from the faying surfaces, and to ream the edges of drilled holes. As it was not convenient to remove the plates far from their location on the side to perform this operation, a special hand tool was devised, which, with a few smart turns, reamed at once both edges of the hole under treatment, and was found to give every satisfaction in its use. Very great care was taken in arranging the butts and edges of this work, in relation to the sidelights, etc., coming through this thick plating, and in addition a very uniform system of tack riveting was adopted for the purpose of getting the plating of this member of the strength girder united over its whole extent, as uniformly as practicable. The beams have forged knees for the sake of lightness.

The deck plating is also shown on the section. A considerable portion on the shelter deck, and a less extent of that on the upper deck, is of high tensile steel. The whole of the doubled portion on the shelter deck, and the stringer on the main deck in wake of the doubled high tensile plating on the side, is hydraulic riveted. The remaining deck plating is principally of such a nature as is necessary to provide suitable floorings, and occupies only a secondary place as regards the structural strength of the vessel. The large openings in the decks, viz., funnels and ventilators, are arranged, as far as practicable, in the same fore-and-aft lines, so that important strakes of plating are run through for long uninterrupted lengths, and these openings have heavy doublings and well rounded corners.

The main bulkheads are formed of high tensile steel, 10-20 inch thick in the lower parts, and 9-20 inch thick up to the main deck. Above this they are 6-20 inch thick, also of high tensile steel. There are eleven main transverse bulkheads, and the subdivision is carried considerably further by the longitudinal bunker bulkheads, by the two bulkheads in the engine room, and by the partial bulkheads in the coal bunkers. The midship section shows how the longitudinal bulkheads are stiffened and braced to the side. These engine room bulkheads, being connected to the longitudinal bunker bulkheads, and of strong construction, form valuable girders contributing to the strength of the ship, and, as they are well stiffened and braced, they are kept up to their work. The main transverse bulkheads have vertical channel stiffeners on one side 12 by 3½ by 3½ by 11-20 inches to lower deck, and flanged stiffeners above, and on the same side horizontal girders 32 inches broad, with a face channel 9 by 10-20 by 4 by 4 by 23-40 inches.

The stem is of cast steel, and is rabbeted to receive the shell plating. The sternpost is a steel casting suitably shaped for supporting a large balanced rudder such as is fitted. The rudder is composed of three steel castings, and the rudder head is of forged steel; all the parts are connected by horizontal flanges, well rabbeted and heavily bolted. The rudder area is 300 square feet; there is one removable pintle, and the steering gear (in duplicate) is below the normal waterline. The spectacle eyes are of cast steel, the two after being riveted to the stern post, and those for the outer shafts being well incorporated with the framework of the hull at positions about 90 feet before the after perpendicular. It may be of interest to note the weights of these items:

Stem	8.37 tons.
Sternpost	59.43 "
Rudder	56.43 "
Four spectacle eyes	60.24 "
Total	184.47 "



SECTION AMIDSHIPS, SHOWING STRENGTHENING OF TOPSIDES AND SHELTER DECK.

TABLE OF SCANTLINGS.

FRAMES—*Inside double bottom* $4\frac{1}{2}$ by 4 by $\frac{12}{20}$ inches for $\frac{3}{8}$ length to $\frac{1}{2}$ inch jogged, and reverse frames 4 by 4 by $\frac{12}{20}$ inches for $\frac{3}{8}$ length to $\frac{1}{2}$ inch jogged. *Outside double bottom* channel 10 by $\frac{20}{40}$ by 4 by 4 by $\frac{20}{40}$ inches for $\frac{3}{8}$ length to shelter deck, with reverse bar 4 by 4 by $\frac{20}{40}$ inches angle to lower orlop deck; to 9 by $\frac{20}{40}$ by 4 by 4 by $\frac{20}{40}$ inches for $\frac{3}{8}$ length to shelter deck, with reverse bar 4 by 4 by $\frac{20}{40}$ inches angle to lower orlop deck.

SPACING.—Frames spaced 32 inches for $\frac{3}{8}$ length to 25 inches aft and 26 inches forward.

FLOORS.— $\frac{1}{2}$ inch under boiler bearers and where necessary: elsewhere $\frac{1}{2}$ inch.

GIRDERS.—Center 60 by $\frac{20-14}{20}$ inches; margin $\frac{16-12}{20}$ inches; remainder $\frac{12-10}{20}$ inches. Center girder angles: top, 5 by 5 by $\frac{15-12}{20}$ inches; bottom 6 by 6 by $\frac{18-14}{20}$ inches; other girder angles, 4 by 4 by $\frac{12-10}{20}$ inches; margin angle, 6 by 6 by $\frac{16-12}{20}$ inches.

INNER BOTTOM.—Center strake, $\frac{16-12}{20}$ inches, remainder, $\frac{15-12}{20}$ inches.

ORLOP AND LOWER ORLOP.—Stringer $\frac{1}{2}$ inch, faceplate $6\frac{1}{2}$ by $4\frac{1}{2}$ by $\frac{15}{20}$ inches, flanged girder $\frac{9}{20}$ inch to fore-and-aft bulkhead.

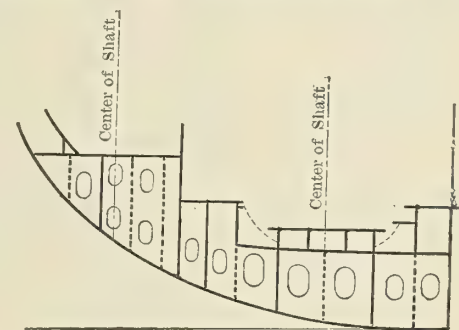
LOWER DECK.—Stringer, 72 by $\frac{12-10}{20}$ inches, remainder, $\frac{8-7}{20}$ inches; beams channel, 10 by $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{10}{20}$ inches on every frame, to 8 by $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{10}{20}$ inches, according to span.

MAIN DECK.—Stringer, 54 by $\frac{12-10}{20}$ inches; next strake $\frac{10-7}{20}$ inches; remainder $\frac{8-7}{20}$ inches; beams, channel 10 by $\frac{20}{40}$ by 4 by 4 by $\frac{20}{40}$ inches on every frame; to 8 by $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{10}{20}$ inches, according to span.

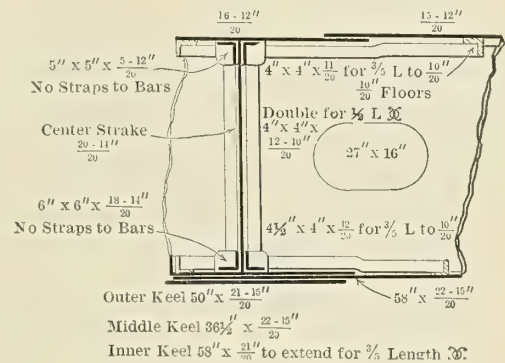
UPPER DECK.—Stringer, 60 by $\frac{15}{20}$ inches high tensile steel to $\frac{1}{2}$ inch mild; second strake $\frac{15}{20}$ inch high tensile to $\frac{7}{20}$ inch mild forward and $\frac{8}{20}$ inch mild aft; third strake $\frac{12}{20}$ inch high tensile to $\frac{7}{20}$ inch mild forward, and $\frac{8}{20}$ inch mild aft; remainder $\frac{10}{20}$ inch. Beams, channel 10 by $\frac{20}{40}$ by 4 by 4 by $\frac{20}{40}$ inches every frame, to 8 by $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{10}{20}$ inches, according to span.

SHELTER DECK.—Stringer, $\frac{17}{20}$ inch high tensile to $\frac{1}{2}$ inch mild; doubling $\frac{22-13}{20}$ inches high tensile; second strake $\frac{11}{20}$ inch mild, doubling $\frac{21}{20}$ inch high tensile; third strake $\frac{10}{20}$ inch mild, doubling $\frac{16}{20}$ inch high tensile; remainder $\frac{10-8}{20}$ inches mild. Beams, channel 10 by $\frac{20}{40}$ by 4 by 4 by $\frac{20}{40}$ inches on every frame, to 8 by $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{10}{20}$ inch, according to span. Stringer angle 12 by 9 by $\frac{20}{20}$ inches.

SHELL.—Outer keel, 50 by $\frac{21-15}{20}$ inches; middle keel $36\frac{1}{2}$ by $\frac{22-15}{20}$



SECTION THROUGH TURBINE SEATING.



SECTION THROUGH KEEL AND CENTER GIRDER.

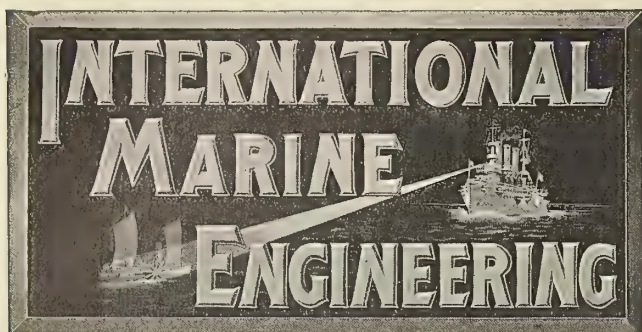
inches; inner keel 58 by $\frac{21}{20}$ inches for $\frac{3}{8}$ length. A strake $\frac{22-15}{20}$ inches; B, C, D, E, F, G, H, J, K, L, M, N, $\frac{21-12}{20}$ inches; O, P, Q, R, S, T, U, $\frac{20-12}{20}$ inches; V, W, X, Y, $\frac{22-12}{20}$ inches; doubling to V $\frac{21}{20}$ inch, extends 105 feet aft of mid-length to 120 feet forward of same; doubling to W $\frac{21}{20}$ inch extends 165 feet aft of mid-length to 160 feet forward of same; doubling to X and Y $\frac{21}{20}$ inch for 240 feet aft of mid-length, to 220 feet forward of same. Forward, where the vessel is closed in, the plating is $\frac{1}{2}$ inch.

FORE-AND-AFT CONTINUOUS BULKHEAD.— $\frac{9}{20}$ inch where curved; remainder $\frac{1}{2}$ inch; base angle continuous 5 by 5 by $\frac{15}{20}$ inch.

ANGLES.—Under decks in way of pillars, 6 by 5 by $\frac{10}{20}$ inches.

(To be concluded)

The number of steamships using the port of Yokohama during 1905 was 7,833, the aggregate tonnage being 14,259,529, and the average, 1,820 tons. There were also 2,217 sailing vessels, aggregating 113,546 tons, or an average of 51 tons. Of the steamers, 2,518 were British, 2,400 Japanese, 1,200 Norwegian, 801 German, and 423 American. Of the sailing vessels, all but 64 were Japanese.



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The Institution of Naval Architects.

Among the papers presented for discussion before the March session of the Institution, several were of particular interest, and all appear to have been thoroughly practical and worthy of attention. One of the most timely may be said to be that one which treats of the construction and launching of the Cunard express steamer *Lusitania*. Among merchant ships, this vessel and her sister are today the most prominent examples to be found anywhere, and their great size and speed render them objects of the utmost curiosity to all who have not had an opportunity to follow their construction through its various stages. It is for this reason that this paper is of such great interest, giving as it does some of the intimate details regarding the construction and the launching.

A paper which excited a great deal of comment in the press of both the United States and Great Britain was that discussing the influence of machinery on the gun power of modern warships. This paper, taking up in some detail the question of the design and placing of steam turbines, producer gas plants and engines operated by crude oil, gives also much attention to details of guns and mountings, and of the turrets in which these guns are housed, and from which they are fired. The subject of weights has received particularly careful attention, because this is the one great item dominating the entire situation. It is shown how savings in weight of machinery due to the utilization of the latest types of ap-

paratus can be translated into an enhanced battery fire by the emplacement of more and heavier guns.

This question of weight, however, is not the whole story. Space comes up for careful consideration, and as the newer types of apparatus represent savings in space as well as in weight, we find that the added value given to the battery is due in part to the doing away with encumbrances of various sorts, such as funnels when internal combustion engines are used. This enables the designer to so place his battery as to command wider arcs of fire than was formerly the case. In a similar manner the magazines may be so disposed in the hold as to render easy the transmission of ammunition to the guns to be served. The whole problem is one of great complexity, involving a careful balancing of one interest against another; and, representing as it does the highest and latest developments in the line of naval construction, the interest excited by the paper is no more than natural.

A paper of great historical interest is that dealing with the evolution of the modern cargo steamer. This delineates the development of the ocean freighter during the past thirty-five or forty years, under two separate headings, showing first how the general appearance of the vessel has changed from time to time in the matter of the fitting or omitting of forecastles, poops, bridge houses and quarter decks. The second portion of the paper is the one of greatest interest, dealing with the development of these vessels from the point of view of internal structure. No attempt is made to go into such special constructions as the turret steamer or the monitor type, nor does the hopper type of the Great Lakes enter into the discussion. In fact, it is the tramp, pure and simple, which has given rise to the entire paper.

Progress is traced from the time of the single-deck tramp of small size up through the two and three-deck vessels, with the intermediate types, showing longitudinal stringers, web frames and deep frames fitted in lieu of deck beams and decks. The final point of development reached is that in which the holds are cleared of the great bulk of the stanchions, these having been supplemented in each case by a large box or girder stanchion carrying a girder along the top to stiffen the deck beams and the structure as a whole.

Marine Disasters.

We have had occasion a number of times recently to call attention to the necessity for some legislation looking to the safety of steamers and other vessels plying in narrowly constricted waters. This, of course, applies equally well to those operating upon the high seas, but in the latter case the immediate danger of collision is much more remote, and, in general, the subdivision of vessels to meet the consequence of such collision is more carefully carried out.

In a number of cases, we have referred also to the necessity of providing effective means for extinguishing, or at least checking, a conflagration upon a floating

structure. A very serious accident of the latter character occurred on the Hudson river on the evening of April 5, though fortunately without loss of life. The steamer *City of Troy*, built in 1877, and recently largely remodeled, was entirely destroyed by a fire, the origin of which is obscured in mystery. It was said that this steamer carried double the amount of hose and fire hydrants required by the rules of the Supervising Steamboat Inspectors; and yet, in spite of this elaborate precaution, the crew, efficient though the event proved it to be, was utterly unable to cope with the situation. The ship was constructed rather flimsily, being almost entirely of wood, and appears to have had no fire breaks of any description. As a result the consuming element was able to run over the entire structure in an incredibly short space of time, and it was due only to the nerve, coolness and training of the officers and crew that a large casualty list was avoided.

We feel that we have worn almost threadbare the subject under discussion, in so far as urging relief is concerned. It is of so much importance, however, and affects more or less directly and very seriously so many interests, that we feel called upon to reiterate our convictions in the matter from time to time, in the hope that eventually something may be accomplished to put an end to a great majority of the cases such as that described.

In connection with the general subject comprehended in our heading, a development which may not be entirely new has recently been noticed in the partial salvage of ships which have been stranded in a way which would formerly have been considered absolutely hopeless. The general subdivision of large steel vessels into a number of separate watertight compartments makes it entirely feasible for any one or any number of those compartments to be floated independently of the others, and it has happened in two or three cases recently that a valuable ship which had run aground in such a way as to preclude all possibility of being pulled off, has been cut in two, and such portion as could be saved has been towed to port, where the missing section is to be replaced by means of a new structure.

The most notable of these cases is that of the White Star liner *Suevic*, which was torn apart by dynamite in order that the after half might be floated and become part of a new ship, presumably of the same name. A similar case has resulted from the wrecking in the same neighborhood of the steamer *Highland Fling*, the bow of which was so securely held by the rocks off The Lizard, that it could not be removed. The ship was cut in two just forward of the bridge, and the stern, kept afloat by the subdivision above mentioned, was towed to a dry-dock, where the work of fitting in a new bow has been progressing. It has been suggested that this method might well be adopted in the case of the Great Northern steamship *Dakota*, wrecked off the coast of Japan. The ship cost about \$3,000,000 (£617,000), and if a large enough section could be saved to warrant the placing of a new bow, it seems probable that the effort would be well justified by the result. This would not give a new

ship, and it would require a large amount of work to give back the old ship, but it would doubtless be better than to abandon the vessel altogether, particularly in view of the fact that she was so new (less than two years old) and consequently had been but slightly impaired in efficiency by the wear and tear of daily service.

Great Britain's Battle Cruisers.

We have adopted the above designation for the three remarkable cruiser battleships which have just been put into the water for the British navy. The *Indomitable* is described in another column, and, with her sister ships, *Inflexible* and *Invincible*, a squadron is formed which is of the utmost strength in both battery power and speed. Each of these ships has a broadside heavier than that of any other vessel afloat, with the sole exception of the *Dreadnought*, and their speed of 25 knots is far in advance of that of any warship larger than a torpedo vessel or scout. The combination, of course, was not obtained without some sacrifices in other directions, such as thickness of armor, and it required the large displacement of 17,250 tons. It is a combination, however, which cannot be approached by any design on the boards of any of the other naval powers, and as such goes a long way toward assuring to the British Empire greater naval supremacy and security than has heretofore obtained.

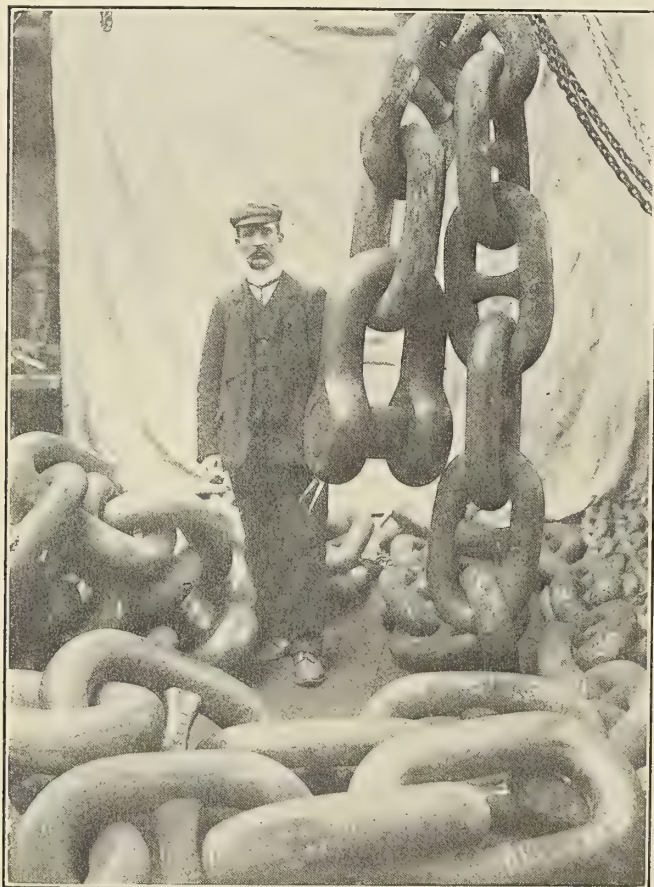
The theory of this design is said to rest on the paramount need of securing at the earliest possible moment accurate information as to the strength and movements of an enemy's fleet. The use of wireless telegraphy has enabled this enemy to extend his scouting screen of destroyers and scouts to such a distance from the main body of the fleet that it would be extremely difficult for a scout of the ordinary type to get within touch of the heavier fighting units, or to obtain much information as to their numbers or whereabouts. This being the case, a type has been evolved which will be able to brush aside the smaller scouting force of the enemy, and to push home a reconnaissance in force, thereby determining the full strength of the opposing fleet. The extreme speed of these vessels will enable them to accept or decline at will a combat with the principal units opposed to them, while the tremendous broadside of eight 12-inch guns would enable them to acquit themselves well in any such encounter which might take place.

In view of the use to which these vessels are to be put, and of the high speed which they are to attain, they have been officially designated as armored cruisers. Possessing, however, as they do, a battery superior to that of nearly all battleships in the world, it goes without saying that each could take its place in the line of battle, and perform the functions usually accredited to the slower moving units of the battle fleet. From the point of view of battery, they are unquestionably battleships; while their thin strake of armor and their unprecedented speed would tend to place them in the ranks of armored cruisers. This dual personality, so to speak, has induced us to call them, as above "Battle Cruisers."

ENGINEERING SPECIALTIES.

A Large Chain Cable.

What is said to be a record in size of cable constructed in 1906, has been manufactured by Brown, Lenox & Company, of Pontypridd. It was for the Japanese government, and the links are forged of material 4 inches in diameter. The weight of each



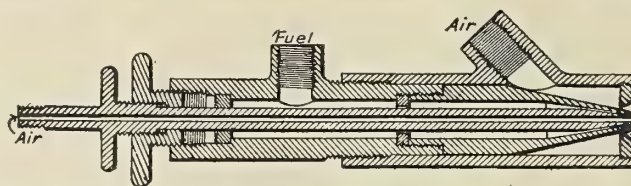
common link is 200 pounds, while the end links weigh 300 pounds. The shackles are especially heavy, weighing 563 pounds each. Some idea as to the size of the chain may be obtained from the photograph, which shows a man standing beside it.

An Oil Fuel Burner.

Experiments have been carried out with this burner at the works of the manufacturer, J. A. Curle, Limited, Homer-road, South Hackney. The oil used is a cheap and crude by-product. The burner will consume equally well any of the ordinary heavy oils. That a high temperature is attained is sufficiently indicated by the fact that two burners of quite moderate size maintained in a molten state a bed of glass weighing about 7 tons, and some 18 inches deep.

The chief interest of the burner lies in its suitability for steam raising. A strong point in its favor for such a purpose is the ease with which it is lighted. With everything starting cold, the burner was lighted with a piece of paper. The fuel is atomized by an air jet, and there is no vaporizer or anything of the kind to heat up. After the burner had been at work for a short time, and there was 20 pounds on the steam gage, the air was shut off, and steam turned on in its place, when the burner continued to work as before. Two sizes of burner were used. Those of the larger size consumed $3\frac{1}{2}$ gallons per hour each, while the smaller took $\frac{3}{4}$ gallon. The volume of air through the larger was about 25 cubic feet, and through the smaller about 10 cubic feet per minute, at a pressure of 18 pounds, which is necessary only where a high localized heat is required. For boiler work a much reduced volume and pressure would be sufficient.

One compressor driven by a 15-horsepower motor runs six large and five small burners, consuming in the aggregate about 22 gallons per hour. The burners are small, the larger measuring

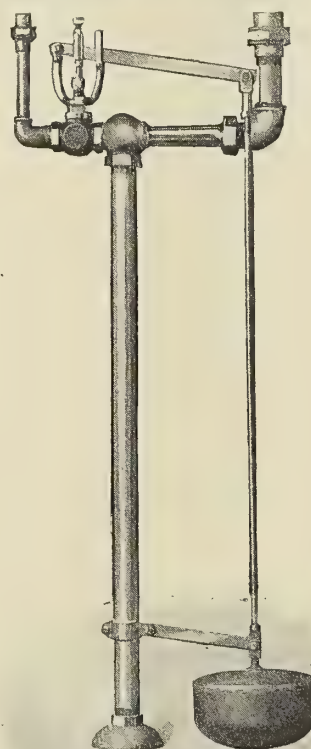


only 10 inches over all by $1\frac{3}{4}$ inches diameter, and the smaller 5 inches over all by $1\frac{1}{4}$ inches diameter.

The air enters in two places. It comes right through the small central hole, and effects atomization, and it reaches the atomized fuel through the larger hole just as it is issuing. It here mixes with the fuel, and promotes combustion. The burner can be regulated down to about one-quarter of its normal consumption by the movement of the inner tube, which is actuated by a differential screw.

The Braender Bilge Siphon.

This siphon is an automatic device for keeping the holds of vessels in a dry condition. It can be placed in a narrow space, and can be so adjusted as to remove bilge water at any desired height from one to twelve feet, with 50 pounds pressure, and if desired it can then be forced as high as 30 feet. As soon as the water reaches the height at which it is desired to be removed, the pressure exerted by the float opens the valve to full area, and

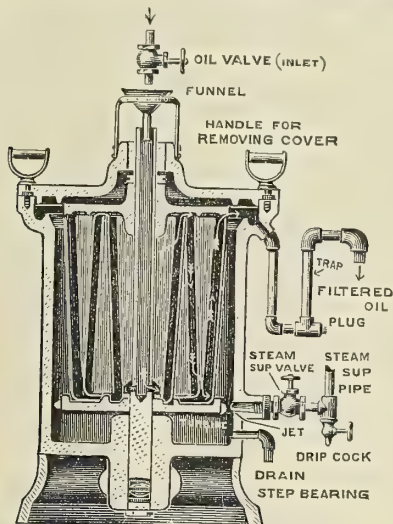


steam is given full sway, causing a vacuum and drawing the bilge water at once to the siphon, whence it is discharged at the rate of from 1,500 to 3,000 gallons per hour, according to the size siphon used. When on the point of stopping, the valve closes easily and automatically, and its action is not disturbed by the rocking of the vessel.

Simplicity of construction and operation, and reliability of action, coupled with a nominal cost for installation and maintenance, commend this device to the service of shipowners and mariners. It is placed upon the market by Philip Braender, 143 W. 125th street, New York.

A New Oil Filter.

The Oil and Waste Saving Machine Company, of Philadelphia, is manufacturing a turbine centrifugal oil filter, constructed on an entirely new principle, for cleaning oil. It is operated with a steam turbine, which requires no care except to turn the steam on and off. This oil is run into the filter through the shaft of the turbine, while in operation. It is then sprayed on the filtering cloth and filter paper, which is revolved by the turbine. The centrifugal force

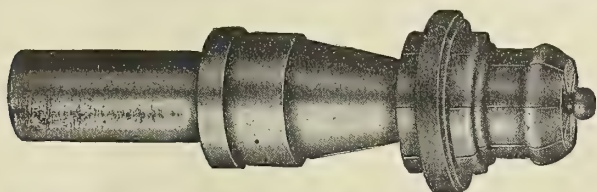


carries the oil through the filtering materials, over the cones, to the outlet.

The oil continually passes through clean filtering material, for the reason that as soon as the filtering materials become dirty or dammed up at the point where the first material is exposed, or near the spray, it then takes a new course through the clean filtering materials. This is a great advantage over the old filtering processes, as in all of them the filtering materials are all exposed to the dirt in the oil at once. The filter can be taken apart in a few minutes and the filtering materials cleaned and used over and over again, with the exception of the paper through which the oil passes, and this is so cheap it is not worth re-using.

The Lucas Pneumatic Sectional Expander.

A new power spring expander is being placed upon the market by W. H. Dangel & Company, 140 Dearborn street, Chicago. It is the invention of D. A. Lucas, and was designed for the purpose of expanding boiler flues rapidly without injury to the tube sheet. It has the same general contour as the Prosser type



of spring expanders, but the taper of the pin or mandrel is much greater in order to prevent any sticking in the sections.

The expander is operated by a small sized pneumatic hammer, and works the flue rapidly in the sheet without working the sheet. It is claimed that the life of a flue sheet will thus be lengthened, since there will be fewer cracks between the bridges, and less elongation in the tube holes. The tool is made of high grade tool steel, and with a view to durability is carefully finished and tapered. The 2-inch size is 8 inches long over all.

It has been announced by the Director of Naval Construction of the German navy that in the future it will be the policy of that navy to make extended use of steam turbines for the pro-

pulsion of ships. Experiments with the cruisers *Lübeck* and *Hamburg*, the former of which has turbines and the latter reciprocating engines, have shown beyond doubt the general superiority of the turbines. It is recognized that there are certain disadvantages, among which are an inability to stop as quickly as the reciprocating engine when running at full speed, and also a present additional cost amounting, so it is said, to about 80 percent. This latter figure will doubtless be much reduced as turbines become standardized.

TECHNICAL PUBLICATIONS.

Statistical Abstract of the World. By Henry Gannett. Size, 3 $\frac{7}{8}$ by 6 inches. Pages, 84 + viii. New York, 1907. John Wiley & Sons. Price, 75 cents, bound in cloth. (London, Chapman & Hall, Ltd. Price, 3s, net.)

The book consists of tables showing area and population for most of the civilized countries of the earth, the population being classified by race, language, sex, birthplace, literacy, school attendance, conjugal condition, and religion; population of large cities; rates of increase of population; vital statistics; illegitimate births; defectives; breadwinners; financial statistics, and railway mileage and shipping; the mineral productions, including all metals and minerals of importance; agricultural products and consumption; livestock and fisheries; manufacturing products and consumption; wooded and cultivated areas; and foreign commerce by countries and by commodities.

The figures given are said to be the latest obtainable, but the dates for the various figures are not mentioned. Of course, in many cases, they would differ throughout any given table, and thus would result in complication. Statistics of the most recent complete year are given in preference to the average for a number of years, as being on the whole nearer to the truth when considered from an up-to-date point of view. The figures have been drawn from a great variety of sources.

Questions and Answers from The Gas Engine. Size, 5 by 7 inches. Pages, 277. Cincinnati, Ohio, 1907. The Gas Engine Publishing Company. Price, \$1.50 (6/-).

This book has been compiled from the "Answers to Inquiries" column of *The Gas Engine*, and consists of the most interesting and valuable items under this heading during the past eight years. These inquiries relate to the design, construction, operation and repair of gas and gasoline (petrol) engines for stationary, marine and automobile use, the answers having been made by some of the best recognized authorities on the various subjects in America and Europe.

The work is divided under seven headings, covering theory of design; mechanical design; marine design; automobile questions; producer gas questions; general questions and trouble inquiries.

American Shipbuilding Returns.

Under date of March 31 the Bureau of Navigation reports the construction during March of 81 vessels, aggregating 72,966 gross tons. Of these, 13 vessels amounting to 66,059 tons, or an average of 5,081 tons, were steamers built of steel. Nine of the thirteen were built on the Great Lakes, accounting for 56,251 tons, or an average of 6,250. The remaining four, aggregating 9,808 tons, and averaging 2,452, were built on the Atlantic coast. Of the vessels built on the Great Lakes, six exceeded 6,300 tons each, averaging 7,007.

The construction for nine months, ending March 31, included 679 sail and steam vessels, aggregating 280,291 gross tons. This makes an average of 413 tons. Of this total, 81 vessels, of 232,264 tons, were steel steamers, averaging 2,867 tons. This compares with a total of 744 vessels of 242,931 gross tons during the corresponding period of the previous year, averaging 326 tons. In this total were included 76 steel steamers amounting to 193,891 tons, or an average of 2,551 tons. The percentage of tonnage of steel steamers to total tonnage was 82.8 for the nine months

just ended, and 79.8 for the corresponding previous period. In addition to the totals above mentioned, there were constructed in the latter period, 258 canal boats, barges and scows, aggregating 64,217 tons gross, or an average of 249 tons. In the previous period, there were also built 258 such unriggered vessels, aggregating 51,371 tons, or an average of 199 tons. The total construction for nine months thus appears to be 344,508 tons in 1907, or an average of 38,279 per month, as against 294,302 tons in 1906, or an average of 32,700 per month.

Obituary.

William L. Guillaudeu, president for eight years of the Old Dominion Steamship Company, died March 22 of pneumonia. Mr. Guillaudeu had been in the service of the company from the age of thirteen. He was also vice-president of the American Bureau of Shipping, a member of the Chamber of Commerce, of the Board of Trade and Transportation, and of the Merchants' Association. His age was fifty-six.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 371.—What amount should be allowed for the clearance of the heads of limit bolts on expansion joints both cold and when hot?

The sizes of pipes are about 9 inches diameter, 10 feet long; and 15 inches diameter and 25 feet long; both being steel pipes designed for a working pressure of 265 pounds.

Is there a formula or rule for same?

W. S. F.

A.—The diameter of the pipe has no bearing upon the subject, which is dependent entirely upon the length of the pipe, the material of which it is made, and the difference of temperature to which it is subjected.

In the two cases cited, a working pressure of 265 pounds gage is specified. This corresponds with a maximum temperature of 411 degrees Fahrenheit. If we assume that when cold the temperature is 50 degrees Fahrenheit, we find that the range of temperature is 361 degrees. The coefficient of linear expansion of wrought steel for one degree Fahrenheit is 0.0000689. For a temperature difference of 361 degrees this figure becomes 0.002487.

The formula by which the linear expansion of such pipe can be determined is: $l = hL (T - t)$; where l is the actual expansion in inches, or fraction thereof, h is the coefficient of expansion per degree difference in temperature, L is the length of the pipe in inches, T is the maximum temperature to which the pipe is subjected, and t the minimum temperature.

In the case of the 10-foot pipe, the expansion figures out as 0.298 inch. For the 25-foot pipe, the figure becomes 0.746 inch. It would thus appear that a clearance of 3-10 inch for the shorter pipe, and $\frac{3}{4}$ inch for the larger would take care of the expansion. In practice, it might be found advisable to allow a slightly greater clearance than this, in order to take care of any irregularity, such as a higher maximum temperature than anticipated, or a lower minimum temperature. So long as the clearance is above that theoretically required, and safely below that necessary for the pulling out of the joint, the results ought to be satisfactory.

Q. 373.—How is the horsepower calculated for the centrifugal pump of a suction dredge discharging 250 cubic meters (327 cubic yards) of sand from a depth of 6 meters (19.7 feet) to a height of 2 meters (6.6 feet) and a distance of 300 meters (328 yards)?

How much heating surface would be required in the boiler? A. B.

A.—The formula would be the same as for that for a centrifugal pump discharging water, but the result would have to be multiplied by a constant, to take care of the fact that the sand would be harder to handle. This constant would vary from 2 to 4, depending upon the looseness of the sand in the bottom.

Multiply the weight of water raised per minute by the total head from depth of dredging to height of discharging, and then divide by the number of units of work per minute in one horse-

power, times the efficiency. This gives the horsepower required at the shaft, for pumps working in water.

In the case in question, the weight of water raised per minute would be $\frac{250 \times 1,030}{60} = 4,300$ kilograms (9,400 pounds). The

horsepower would be $\frac{4,300 \times 8}{4,500 \times 0.68}$; where 0.68 is taken as the

efficiency of the pump, and 4,500 represents the number of kilogrammeters of work per minute in one horsepower. This figures out as 11.3 horsepower, and applying our constant to transfer the result into power required for sand, we find it would be from 23 to 45 horsepower, an average figure being about 35.

The heating surface of the boilers would be about 0.25 square meter (2.7 square feet) for each horsepower. This would call for approximately 9 square meters (100 square feet).

Q. 374.—Are all foreign steamships (with the exception of Canadian boats) such as the French and German, English and Scandinavian passenger boats, subject to inspection by the United States Inspectors of Steamboats on entering an American port; and if so, are American ships subject to inspection on entering a foreign port regularly yearly, the same as here, not considering breakdowns?

2. Is a pump doing more work in forcing water to a height of 25 feet than in lifting it the same height? P. G.

A.—The laws governing the Steamboat Inspection Service of the United States provide that all foreign steam vessels carrying passengers from any port of the United States to any other place or country shall be liable to visitation and inspection by the proper officer in any of the ports of the United States. When, however, such vessels belong to countries having inspection laws similar to those of the United States, and have unexpired certificates of inspection, issued by the proper authorities in the countries to which they belong, they shall be subject to no other inspection than is necessary to satisfy the local inspectors that the condition of the vessel, her boilers and life-saving equipments, are as stated in the current certificate of inspection.

2.—Theoretically there is no difference in the work of a pump between forcing water to a height of 25 feet and lifting the same quantity of water to the same height. Practically, however, it is found somewhat easier to force water to this height than to lift it, because of the fact that unavoidable small leakages in the valves render it impossible to lift water to the height represented by the pressure of the barometer (about 34 feet) and the nearer this lift is reached the more difficult does it become to fulfil the requirements. With pumps in perfectly good order, 25 feet ought to offer little trouble on this score, but it is just about this point that the difficulty begins to accumulate.

A German manufacturer has made a number of experiments in order to ascertain the comparative durability of various metals when exposed to the heated exhaust gases from internal combustion engines. The experiments indicate that bronze and copper are least adapted to endure exposure; nickel and brass are possessed of more enduring qualities, while machine steel, nickel steel, and cast iron show little depreciation from exposure. Cast iron stood the test far better when not finished, but even finished cast iron proved to be well suited for exposure of this character. The exhaust gases in the experiments referred to had a temperature of 700 degrees F.

The Partial Salvage of the Suevic.

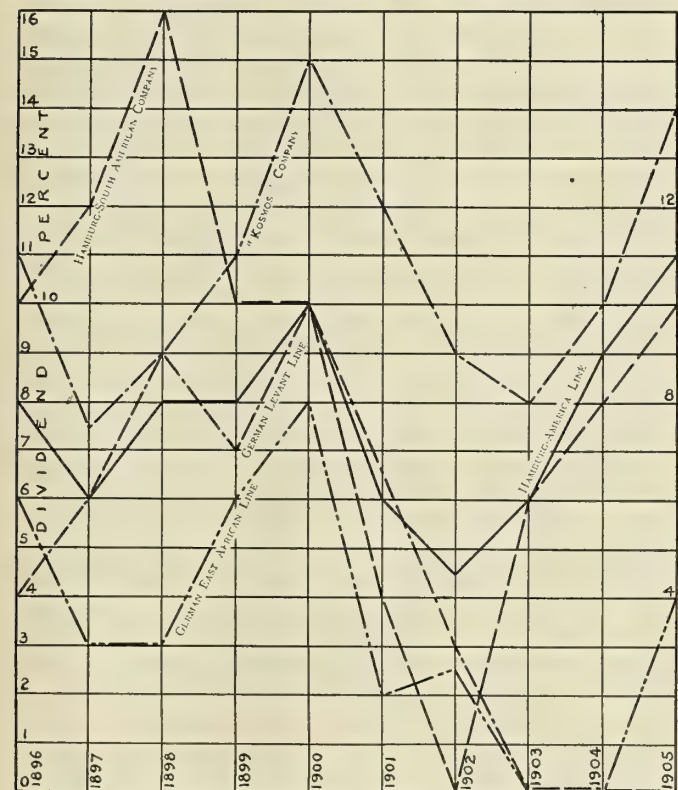
The White Star liner *Suevic*, which went ashore on a reef near The Lizard, March 17, and was expected to become a total loss, has been partially saved in a peculiar manner. By means of an extensive use of dynamite the vessel was cut in two not far from amidships, and the after part, being finally severed, and being floatable by reason of her extensive subdivision by watertight bulkheads, has been towed into port. The forward portion of the vessel is firmly fixed on the reef, and cannot be saved.

The *Suevic* was built in 1900 by Harland & Wolff, Limited, Belfast, and measured 550 feet 2 inches by 63 feet 3 inches by

39 feet 9 inches deep. Her net and gross tonnages were respectively 8,108 and 12,500. She was propelled by twin screw quadruple expansion engines with cylinders measuring respectively 22, 31½, 46 and 67 inches in diameter with a common stroke of 51 inches. She was fitted with four masts, schooner rigged.

German Shipping Dividends.

The five principal shipping companies using Hamburg as the main port have been extremely prosperous in almost every one of the last ten years with the exception of two companies whose dividends since 1902 have been small. The diagram which we present shows the dividends declared by each of these companies in each of the years from 1896 to 1905 inclusive, and includes the Hamburg-America Line, the Hamburg-South American Company, the Kosmos Company, the German-East African



Line and the German Levant Line. It has been explained that the lack of prosperity of the latter has been due to keen rate-cutting competition.

The average rates of dividend for the first and second five year periods, and the entire ten years, were as follows:

	1896-1900	1901-05	1896-1905
Hamburg-America Line	8	7.3	7.65
Hamburg-South American Company.	11.6	5.6	8.6
Kosmos Company	10.7	10.6	10.65
German East African Line.....	5.2	1.7	3.45
German Levant Line	7.2	1.9	4.55

British Shipbuilding Dividends.

Returns from a number of the large shipbuilding companies in Great Britain indicate a considerable degree of prosperity. During 1906, dividends are reported to have been paid as follows: London and Glasgow Engineering & Shipbuilding Company, 16.11 percent; R. & W. Hawthorne and Leslie Company, 12.5 percent; Sir W. G. Armstrong, Whitworth & Company, 12.38 percent; Vickers, Sons & Maxim, 12.11 percent; William Doxford & Sons, 11.66 percent; Parsons Marine Steam Turbine Company, 10 percent; John Brown & Company, 8.3 percent; Bow, McLachlan & Company, 6.67 percent; S. P. Austin & Son, 6.44 percent; Richardson, Westgarth & Company, 6 percent; the Thames Iron Works, Palmers Shipbuilding & Iron Company, D. & W. Henderson & Company and Swan, Hunter & Wigham Richardson, each 5 percent.

The American Seamen's Friend Society, now located at 76 Wall street, New York, is about to erect a building on West street, for which purpose Mrs. Russell Sage has donated \$150,000 (£31,000). The British and Foreign Sailors' Society has presented to Mrs. Sage, as a souvenir of the occasion, a bust of Nelson mounted on oak from the timbers of Nelson's flagship *Victory*.

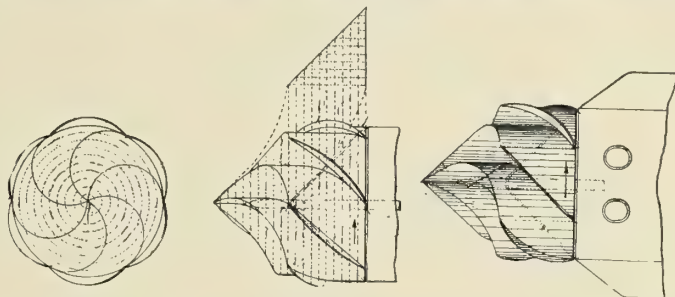
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

838,098. PROPELLER. ANDRE GAMBIN, PARIS, FRANCE.

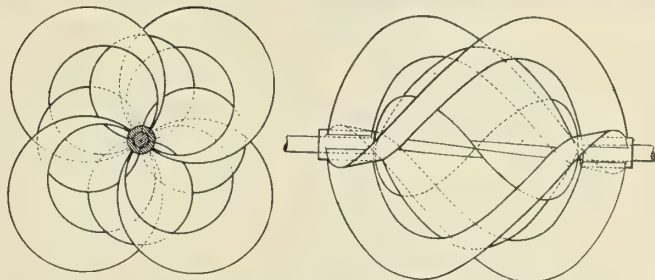
Claim.—3. A propeller-blade whose outer surface starts as a cylindrical surface at the periphery of the propeller and merges into a helical surface as it continues to the point, and whose inner surface is an irregular surface sloping away from the edge of the blade until it meets the



outer surface of the next blade, in combination with a crescent-shaped extension forming an auxiliary blade extending from the base of the propeller at an angle of forty-five degrees thereto to the point of intersection of the edge of the cylindrical surface of the blade with the edge of the helical surface. Four claims.

838,313. PROPELLER. JOSE FOLA, VALENCIA, SPAIN.

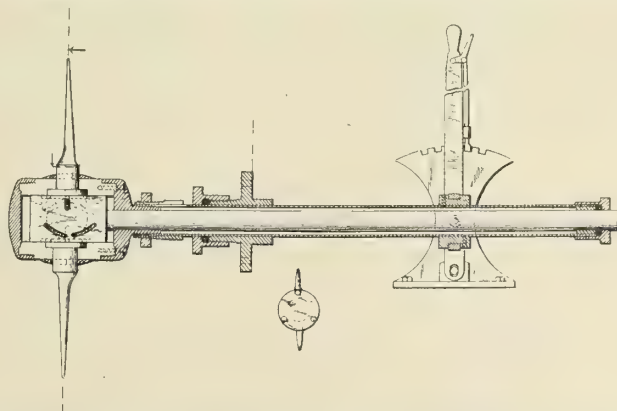
Claim.—1. A propeller the blades of which are of helicoidal curvature such that their surfaces can be described by the radius of a sphere



when said sphere is caused to rotate simultaneously relatively to two of its diameters, the edge of the blade lying on the surface of the sphere, and the blade being attached to the shaft along a diametral line. Three claims.

838,532. REVERSIBLE PROPELLER. WILLIAM C. FISCHER, HUNTINGTON, N. Y., ASSIGNER OF PART TO MAURICE LACHMAN, NEW YORK.

Claim.—1. In a reversible propeller, the combination with the propeller shaft, of a block secured thereto, having a plurality of cam-slots on each of its faces, said cam-slots being disposed at different angles to the path



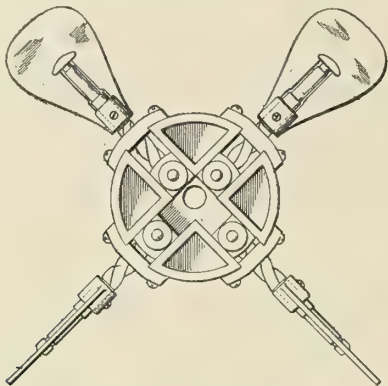
of movement of said block, propeller blades having followers in the form of pins projecting into said slots, means for holding said propeller blades against said block, and means for causing relative movement between the cam-slots and the followers, thereby shifting the angle of the propeller blades. Seven claims.

841,961. MARINE VESSEL. JOHN F. GRAY, PORTSMOUTH, N. H.

Claim.—1. A vessel having a pocket in the side thereof, an inclined lifeboat adapted to be nested in the pocket, the vessel and lifeboat having registering ports or manholes, and means for closing said manholes, said means comprising hinged doors, devices for removably holding the doors closed and means operable within the vessel or lifeboat for holding the vessel port cover in place. Six claims.

839,897. MARINE PROPELLER. OZRO P. SMITH, SOUTH FRAMINGHAM, MASS., ASSIGNOR TO JOHN L. YOUNG, SOUTH FRAMINGHAM.

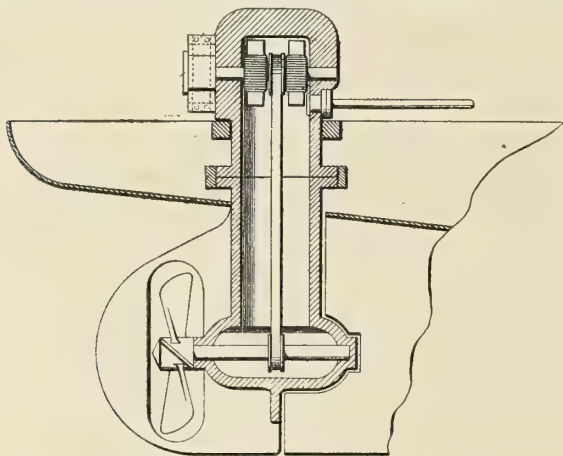
Abstract.—The propeller is located in a submerged well below the water-line of the vessel and comprises four blades which are alternately moved



out away from and drawn back toward the shaft. These blades are given a feathering or turning motion as they are moved in and out, the blades during their idle or return travel standing in a plane at right angles to the shaft, and during the operative part of their stroke or travel standing in planes parallel with the shaft. Seven claims.

840,548. BOAT-PROPELLER. GEORGE F. ATWOOD, WAKEFIELD, MASS.

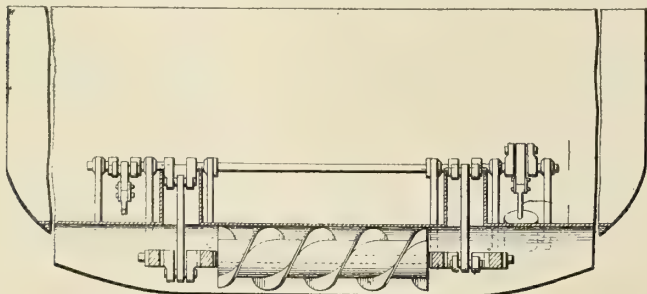
Claim.—1. The combination of a boat, a vertically-disposed, axially-movable casing journaled in a bearing on the boat, an insulating disk having an annular projection extending through the casing wall and secured thereto, a shaft journaled in the lower portion of the casing and provided at a point within the casing with a band-pulley and at a point outside the casing with a propeller, a shaft journaled in the upper portion of the



casing and provided within the same with a band-pulley, a band or belt connecting the pulleys and contained in the casing, an electric motor comprising rotary armatures fixed directly on the second mentioned shaft, a tiller having a disk opposed to the insulating-disk of the casing and pivotally connected thereto, a source of electric energy, and co-operating means on the disks for controlling the supply of electric energy to the motor. Three claims.

841,243. PROPELLING DEVICE FOR STEAM VESSELS. JOSEPH GREAVES, RADERSBURG, MONTANA.

Claim.—A vessel provided with a tunnel or channel at its keel, supporting arms disposed across said channel, a driving shaft rotatably mounted



in said arms, a cylinder open at its opposite ends and mounted upon said driving shaft, a channel plate secured to the periphery of said cylinder in a spiral path, and a blade secured in the vertical channel of said plate. One claim.

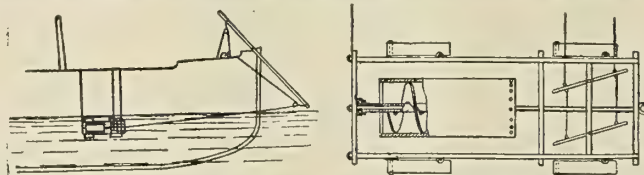
British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

20,232. SHACKLES. J. R. SPURLING.

Relates to slip shackles of the type in which the closure is effected by a hinged bar, the free end of which may be secured and released by a rotating recessed member. The shackles are suitable for disconnecting ships' boats and anchors, slipping moorings, releasing tow ropes, etc. The locking-bar is hinged to an arm, and its free end engages a radial recess in the head of a spindle which is journaled in the other arm. A spring may be provided to return the bar to its closed position. An operating arm is secured to the spindle, and carries at its upper end a locking-piece which, under the action of a spring embraces one arm of the shackle. Stops may be provided to limit the motion of the locking-piece. Eyes may be provided to carry a chain or cord by which the shackle may be operated from a distance. In a modified form, the U-shaped locking-piece is replaced by a single arm acted upon by a spring and engaging a slot in the arm of the shackle.

20,293. CLEANING SHIPS' HULLS. J. T. BEELENDORF.

Relates to certain detail improvements in that class of cleaning apparatus which comprises a rotary scraper and a propeller for rotating it, rudder plates for raising or lowering the scraper in the water, adjustable pres-



sure plates for causing the scraper to stay in contact with the hull, and means operated from the deck for actuating the cleaner. The actuating rope is led from the cleaner over a pulley carried at the end of a spar, which is universally mounted at the bows of the vessel.

20,767. SCREW PROPELLERS. W. SCHMID.

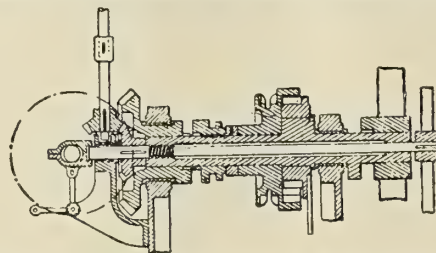
The blades are feathered by fluid pressure. The propeller shaft is hollow, and within it is mounted a tube, the couplings of which are provided with longitudinal grooves where they meet the inside of the shaft. The propeller blades are kept in place by nuts. A stationary plate is fitted in the underside of the blade boss, and the boss is cut away so that it may turn slightly on the circular part of the plate. Pressure is admitted on one side or the other by means of cocks, which may be placed in communication with the tube or the annular space.

20,813A. SOUNDING APPARATUS. KELVIN OF LARGS, W. THOMSON, BARON, AND KELVIN & JAMES WHITE, LTD.

In a navigational sounding apparatus, especially for taking flying soundings from amidships or from the fore-bridge by the aid of a boom, a traveller is provided to which the leading block is secured in such a way as to allow it to adapt itself readily to the sounding-wire. A traveller for use on a horizontal boom has ends provided with internal rings covered with greased leather, and it can thus be moved along the boom, without jamming, by means of ropes. The sounding wire passes over a pulley mounted in a casing pivoted at right angles to the spindle of the pulley, to brackets on the traveller. The casing has holes for the passage of the wire, and a hinged part, which enables the wire to be readily placed on the pulley or removed. The hinged part is locked and closed by a pin.

21,428. STEERING-GEAR. M. ARCHER.

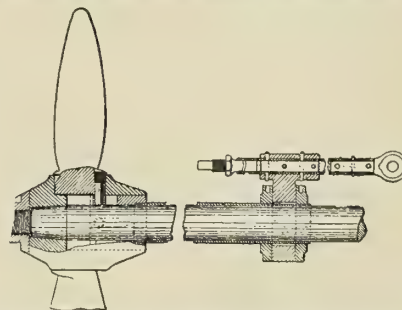
The first-motion shaft is fitted with clutches whereby the gear may be operated either by hand or by fluid pressure. When operated by hand, the steering-wheel drives the eccentric and by means of the epicyclic gearing the chain wheel, by which the rudder head is turned. The parts of the



clutch are put into gear when fluid-operated. The controlling valve of the steering engine is actuated by the hand-wheel, the first-motion shaft being rotated by the bevel wheel on the engine crank shaft. The rotation of the shaft operates the rudder, and also brings the screwed spindle back to the position it originally occupied, closing the controlling valve and bringing the engine to rest.

21,934. SCREW PROPELLERS. J. I. THORNYCROFT & CO.

In feathering propellers, the blade is formed with a screwed shank. An eccentrically arranged, inwardly projecting pin engages an inclined slot in a slidable sleeve, and, by sliding this sleeve, the blades are feathered. A pin



engages a slot in the sleeve and prevents relative rotation between the shaft and the sleeve. Motion is transmitted to the sleeve by a tube from an arm, which is held between collars. A rod is operated by the hand wheel and lever, and the outer end is supported by the spindle, secured to the stern tube. In rotating the blade, it moves slightly towards or away from the center of the shaft.